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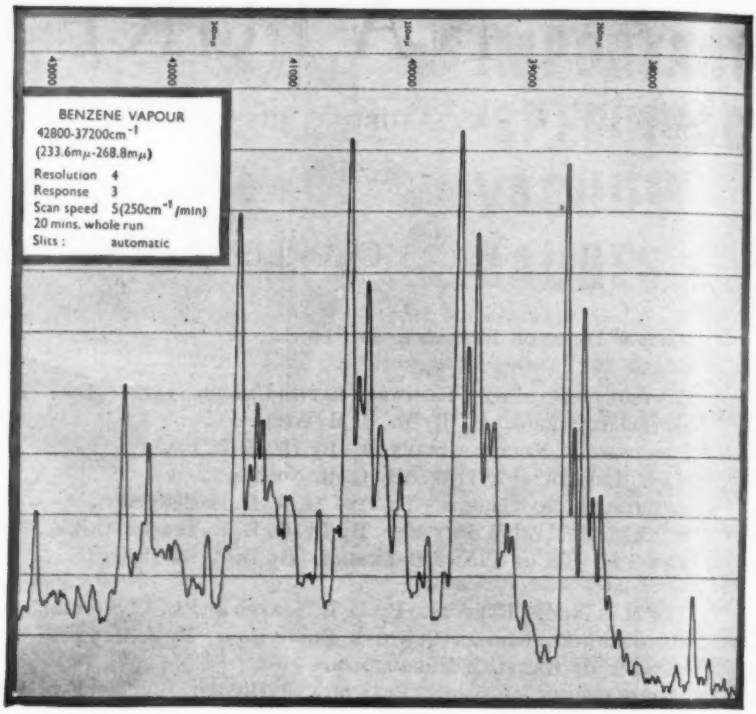

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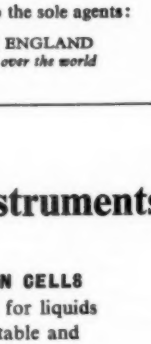

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BRITISH DEFENCE RESEARCH AND DEVELOPMENT

THE pattern of British defence policy can seldom have been so quickly transformed as that set forth in the Report on Defence* issued on February 17. Claiming that during the third year of the Five-year Plan for Defence the Government's broad defence policy had undergone no major change, the recent White Paper on Defence admitted that it might be decided not to rely exclusively on fixed-site missiles as the successor to the medium bomber armed with the stand-off powered bomb. Accordingly, the possibilities of mobile launches, whether aircraft or submarines, for long-range delivery of nuclear warheads are being investigated.

In opening a debate on this White Paper on February 29, the Minister of Defence, Mr. Harold Watkinson, paid a tribute to the work of his Chief Scientific Adviser and his team of experts, and referred to the immense technological changes taking place in defence by new methods of computation and production, which are enabling problems to be solved which could not have been even formulated with precision a few years ago. But, apart from suggesting that we might be led to give greater emphasis to mobility and flexibility, he said nothing further to foreshadow his announcement on April 13 that the Government has decided to discontinue the development of *Blue Streak* as a military weapon. Indeed, on February 29, he had endorsed what Mr. Sandys, his predecessor as Minister of Defence, had said in the Defence debate in February 1959, that *Blue Streak* was going ahead, but that we would watch the progress of other developments in the United States and elsewhere, and that with the rapid advances of science, which are constantly upsetting earlier assessments, strategic plans and weapon programmes can never be regarded as permanent or inevitable. Specifically, he said that what we have learned from the development of *Blue Streak* has been of some help to the Americans, and that we have already learned much both in the technique of propulsion and in the design of the very complicated guidance and computation systems that are the necessary concomitant of any ballistic missile. Final decisions on the balance Britain should hold between fixed-site missiles and mobile launchers, Mr. Watkinson said then, had not been taken, and he would like much more information about *Skybolt*, a ballistic missile of considerable range which could be launched from an aircraft, and also about the future development of *Polaris*, a solid-fuel rocket generally designed for a mobile role, and he was also having examined more closely the defence aspects of space research, at which he thought we need to look very carefully. Lord Hailsham, too, in the House of Lords debate on March 9, had been equally emphatic that British policies must be constantly open to revision, and equally he stressed the fact that the nuclear weapon, though in his view indispensable, is no more than one of the factors that make up defence policy. Of the £1,600 million covered by the Defence Estimates, no more than about 20 per cent could be attributed to the nuclear deterrent and its defence, and 10 per cent to the deterrent itself. About 14 per cent was spent on research and development, and in this connexion Lord Hailsham affirmed that we must be ruthless in our determination to scrap anything which cannot be justified, and resolute to support whatever is necessary by way of research and development.

Little was, in fact, said about defence research and development, though, in the House of Commons, Mr. J. Grimond suggested that, taking research into account, the whole of the nuclear weapon programme of research and development would represent 15–20 per cent, and Sir Alexander Spearman asserted that on research alone the United States is spending more than double our defence budget. Mr. Watkinson asserted, however, that it is much nearer 15 per cent, but on April 13 he admitted that the cost of completing the *Blue Streak* project would be between £500 and £600 million. None of the £95 million already spent would be wasted if it was decided to go ahead with *Blue Streak* as a launcher for a space satellite ; but the admitted costs for *Seaslug*, *Thunderbird* and *Firestreak* bring the estimated missile bill to some £205 million, leaving out of account the stand-off weapon of the Royal Air Force designed to be launched outside the range of the enemy's defences, for which no figures are available in the Auditor-General's recent analysis. Incidentally, Sir Frederick Brundrett, former chief scientist to the Ministry of Defence, who still considers that *Blue Streak* could provide at least until 1970 an effective independent British contribution to the Western deterrent, has also supported the submarine-launched missile in preference to an air-launched missile.

There are two points made in these Defence debates that are of particular interest to the scientist and technologist. First, the inordinate time taken to plan, develop and produce the more complicated and technical weapons of itself increases the expense, and Lieut.-Commander S. L. C. Maydon suggested that it might be worth while to set up a small committee of experts consisting of an experienced industrialist, a senior Service officer of up-to-date ideas and a man experienced in time-and-motion study to look into the possibility of reducing the time taken to design and build a ship, aircraft, tank or other equipment. Commander Maydon did not suggest that this would lead to more than comparatively minor savings or short cuts, but in view of the magnitude of the expenditure involved they could be well worth while.

* Report on Defence 1960. Pp. 18. (Cmnd. 952.) (London : H.M. Stationery Office, 1960.) 1s. net.

The second point underlines a comment made by Vice-Admiral J. Hughes-Hallett in a defence debate last year, namely, that no one outside a small circle of Service officers, Government officials and possibly senior Ministers could hope to answer the vital questions, because he cannot possess the information which is the essential basis of any opinion worth while. Viscount Bridgeman quoted an editorial comment in a Service journal on a lecture by General Sir John Cowley: "It is one of the tragedies of our modern times that the speed of technological advance is so great that no officer who has left the Services can hope to keep abreast of new inventions. One of the results of this is to deny to the Services the benefit of the advice and counsel of their senior retired officers. They are all out of touch within six months or a year of retiring".

This, as Admiral Hallett put it, is a novel and dangerous position. Very few people indeed possess the vital information without which the study of tactics and strategy is a waste of time, and a perusal of this year's debates on defence, on the Air Estimates, the Navy Estimates and the Army Estimates provides evidence enough of this, despite all the efforts of many members of Parliament to obtain factual and unbiased information. Mr. E. L. Mallalieu's comment in the debate on March 9 on the Navy Estimates that members of Parliament have nothing like the sources of information available to members of Congress in the United States for making suggestions or criticisms on the Estimates should be noted. Nor can it be said that the White Paper itself adds much to the scant information available for discussion on the scientific and technical aspects of British defence policy. Stress is laid on the increasing need in the Services for those with scientific and technical knowledge and skill, and the excellent equipment of the Government's research and development establishments, which are staffed by scientists and engineers of the highest quality. The maintenance of the strength of these establishments is a vital feature of the defence plan. Certain scientific establishments have now been transferred to the War Office from the Ministry of Supply, along with the functions to which they are related, and every care is being taken to ensure that the scientific and technical resources, and the unity of professional staffs, which have been progressively developed over recent years, are preserved under the new arrangements. With the disappearance of the Ministry of Supply, the Ministry of Aviation has been given responsibility for the supply of guided weapons, including ballistic missiles, of much radar and other electronic equipment, and of nuclear weapons.

However, three important contributions to informed discussion have recently become available. The first is Mr. Alastair Buchan's examination of the implications of interdependence published by the Institute for Strategic Studies, to which reference was freely made in the defence debates. The second is Prof. P. M. S. Blackett's Tizard Memorial Lecture delivered before that Institute on February 11 and published in *Nature* of March 5, p. 647. The third is the Report on Basic Research in the Navy by the United States Naval Research Advisory Committee*. Reference was made to the latter report in *Nature* of February 27, but was confined to only one interesting aspect of the inquiry—the possibility of measuring the effectiveness of research and development—and by no means indicates the extent of the contribution which the two volumes of this report could make to the public understanding of the interrelations of defence and civil research. Besides this model for the discovery and application of knowledge, which is the major appendix constituting Vol. 2, together with some man-power studies bearing on research and development, there is a chronological list of naval technical developments to illustrate the impact of science and technology on the evolution of the United States Navy and a brief bibliography. The first volume comprises the conclusions and recommendations of the Naval Research Advisory Committee and the report to that Committee on basic research in the U.S. Navy, prepared by A. D. Little, Inc., setting forth the nature of basic research and its relation to military ends.

It is these conclusions and recommendations that deserve to be noted at the present moment when misgivings are being expressed about the soundness of the scientific and technical advice being tendered on defence matters in Britain, and the adequacy of existing arrangements to ensure that such advice is timely and effective. The report points out that in the past basic research has transformed naval strategy and tactics by its findings in such fields as radar, inertial guidance, missile propulsion and nuclear propulsion, and suggests that the United States Navy should support enough research in each area of interest to provide effective coupling and judgment for its own needs. That may well be too much a counsel of perfection for Britain, with her more limited resources; but it is assuredly true for her also that each Service Department should be competent and alert to appreciate the scientific findings of its own or other workers, and the significance of such findings to its own responsibilities and functions.

The Naval Research Advisory Committee considers that the basic research effort in the United States Navy should be about doubled to restore the former relation of basic research to the total research and development effort, and this would bring that effort nearer to the 16 per cent now current in progressive scientific and engineering industries. The report does not attempt to detail the programme proper, but it suggests that the Office of Naval Research should prepare detailed programmes in some seventeen fields of scientific work related to the missions of the Navy. Some of these are obvious prime or major responsibilities; others require effective co-ordination with what is being done elsewhere. The fields specifically listed are: physics; astronautics and aero-

* U.S. Department of Defense. Department of the Navy: Naval Research Advisory Committee. Basic Research in the Navy: Report to the Secretary of the Navy by the Naval Research Advisory Committee. Report prepared by Arthur D. Little, Inc. Vol. 1: Pp. xi+69. Vol. 2: Pp. 1+102 (Washington, D.C.: Department of the Navy, 1959.)

nautical engineering ; material sciences ; electronics ; mechanics ; medical sciences ; biology and biological sciences ; oceanography ; chemistry ; geography ; psychology ; operational research ; meteorology ; astronomy and astrophysics ; mathematics ; combustion ; earth physics.

It is not suggested, of course, that the U.S. Navy should attempt to cover all aspects of these fields, and it is recognized that, in planning research, use should be made of scientists and administrators from the universities and industry. Moreover, when a total programme has been prepared, a critical review is needed, to ensure that the total cost is within the budget. Although the report says comparatively little about the co-ordination of naval research in the United States with that of basic research for the other Services, apart from the admirably chosen examples of the way in which advances in basic science and technology have affected naval tactics and operations, these proposals demonstrate the dependence of naval efficiency on an adequate national effort in research and development, and the existence of appropriate means of ensuring that that effort is adequate and that its results are effectively communicated.

It is here that Prof. Blackett's lecture is so pertinent. He gives us much more than a thoughtful study of the influence of one man of outstanding ability. He indicates the qualities that are desirable in those, both within the Services and outside, who are called upon to decide on the programmes of research and the resources to be allocated to them. His lecture, too, is highly suggestive as to the conditions which favour the throwing up of such men and establishing co-operation and confidence between the Services and scientists and technologists. His comments both on the Defence Research Policy Committee and the Advisory Council on Scientific Policy, as well as on the importance of the Institute for Strategic Studies are also constructive, and it should be noted that Prof. Blackett considers that the Defence Research Policy Committee has proved a more effective instrument than the Advisory Council on Scientific Policy.

Whether, in fact, the Defence Research Policy Committee is still sufficient may well merit re-examination. It has been suggested that the system by which each of the three Services has a chief scientific adviser with a staff of scientists, and the Ministry of Defence a chief scientific adviser to the Government is insufficient, and that there should also be a scientific member of each of the boards or councils of the three Services and of the Chiefs of Staffs Committee. That seems, however, unlikely to be effective unless the other members of those bodies are capable of assessing the significance of scientific advice, and the solution of the problem may well turn on that of men and training as Prof. Blackett's lecture indicates, and the finding of men possessing the qualities which command respect from the Services and scientists alike and capable of understanding the issues involved and inspiring the co-operation required. Mr. F. J. Bellenger, in the debate on the Army Estimates on March 9, when urging the importance of senior officers in all the Services being equipped with scientific knowledge and training, rather implied that this is not yet generally the case.

Given those conditions—appropriate organization, an adequate supply of men of the high qualities, vision and sound judgment, as well as conditions which favour the informal contacts and discussions to which Admiral Hallett referred, with which any formal organization should be supported—it will still be difficult enough to reach wise decisions on strategy and tactics. Apart from the danger that political prejudice or uninformed judgments may take control, there is always the risk in this rapidly changing and complex technological world that matters of tactics may determine strategy, and even the policy behind strategy, and here such books as Alastair Buchan's "NATO in the 1960's : The Implications of Interdependence"* are valuable.

In this field and at this stage the scientific and technical aspects cannot be sharply separated from the political. All that the scientist or technologist as such can hope to do is to see that the former aspects are adequately and effectively presented, and that their implications are grasped. If, as *The Economist* has suggested, the key question of our time is where in the civil field the investment of extra resources in research might pay the best dividends, or what is the scale of research and development it might be worth while devoting to particular industries or sectors of the economy, the question of priorities is equally vital in defence. Indeed, it is the factor which should decide what we can afford to spend on defence ; and apart from any risk that our research effort generally may be affected by considerations of prestige rather than sound economy, the suggestion that too much effort has been put into nuclear energy, electronics and aircraft, and too little into machine tools and shipbuilding, should not be dismissed without examination.

Mr. Buchan's book is primarily an attempt to grapple with the problems which confront the North Atlantic Treaty Organization in its second decade. He seeks first to define those requirements and then examines the adequacy of existing arrangements and resources to meet those demands. In effect, he considers that the channelling of an increasing proportion of our resources into nuclear weapons has left us incapable of defending local or secondary interests by traditional methods, and he maintains that conventional forces are not outmoded. He questions also the wisdom and utility of the policy which has given Britain an independent force with nuclear bombs and bombers. Deterrence, he argues, has replaced defence, and he would transfer to NATO the British independent nuclear force.

That view is not accepted by Prof. Blackett, who, in a comment appended to the book, rejects the idea of creating a European system of intermediate-range

* NATO in the 1960's : The Implications of Interdependence. By Alastair Buchan. Pp. xii+131. (London : Weidenfeld and Nicholson, Ltd., 1960.) 12*s.* 6*d.* net.

ballistic missiles; he believes that such a system is technically and politically impossible, but that the long-range bomber and inter-continental ballistic missile systems of the United States are, in fact, adequate and that the present state of affairs with France, and presumably other countries eventually, following the British lead in producing their own nuclear weapon system, is less dangerous. That view, however, does not discount what Mr. Buchan urges about the promotion of co-ordination and co-operation within NATO, though it might make it more difficult to achieve some of the underpriming of interdependence which Mr. Buchan also requires, and which includes, for example, giving NATO itself a small research budget of, for example, £1 million a year, to enable it to stimulate lines of research in which, for any reason, no national government could be induced to take sufficient interest independently.

Mr. Buchan's book has clearly profoundly influenced thinking on defence policy, and whether or not his own conclusions are accepted, the defence debates showed a growing recognition both of the increasing importance of NATO, and that no other country or even group of countries in the free world, besides the United States, has a wide enough scientific and industrial base to develop the diversity of complex weapons systems needed to maintain a strategy of deterrence. This interdependence was widely recognized in the debates in the Houses of Parliament, and also, though less clearly and more reluctantly, the dependence of Britain on the technological resources of the United States. The improvidence of duplicating highly technical work on defence problems here and in the United States was, however, admitted, and there was some welcome common ground between political parties, notably in regard to co-operation and the importance of NATO, and also in regard to mobility and the importance of conventional forces, even if the implications for recruitment scarcely seem to have been realized as yet. In the debate on the Navy Estimates on March 7, the Civil Lord of the Admiralty, Mr. C. Ian Orr-Ewing, stressed the importance of the Dounreay reactor for testing British reactor design and the components of British-made machinery in the nuclear submarine programme, but in the same debate some considerable misgivings were expressed about the research arrangements under NATO. Perhaps two of the most significant speeches were those of Sir Fitzroy Maclean on March 1, who urged the re-appraisal of the whole question of an independent deterrent, quoting General Cowley's opinion that the British contribution to the peace of the world could be far more useful in other directions than in producing weapons which are only useful because of their threat, and of Mr. Antony Head on April 27, who likewise spoke against undue reliance on nuclear weapons and urged a balance between such weapons and conventional forces. Pointing out that Britain is only spending 3 per cent of the expenditure of the United States on nuclear research developments and armoury, he questioned how far we could afford such developments; he said he fears that it could only be done by making our conventional forces ineffective.

Lord Shackleton, however, took a very contrary view, in referring in a House of Lords debate on May 3 to the decision to abandon the development of *Blue Streak* as a missile. Quoting Prof. W. R. Hawthorne's opinion, expressed at a meeting of the Parliamentary and Scientific Committee, that if we shut out a new technology or let it filter slowly through from some foreign country, we should reduce the resources of skill and experience upon which our designers can draw, Lord Shackleton was urging not so much development of the independent deterrent as of a space-research programme offering prospects of a major scientific and economic development. Lord Hailsham had said in the earlier debate on defence on March 9 that he was convinced that humanity must find a means of abolishing or controlling nuclear and other weapons, or sooner or later disaster would occur; but that the abolition of nuclear weapons must be considered in the context of general disarmament. On May 3 he pointed out that if by 'independent deterrent' we meant one of such power that by the use of it alone we could hope to engage one of the Great Powers on our own with hope of victory, in his judgment Britain has never had and is unlikely to have such deterrent. All we have at present is a significant part of the Western deterrent under our control.

Apart from linking this question of a nuclear deterrent with that of disarmament in general, Lord Hailsham's speech on May 3 is of interest for what he said about the close balance of the arguments both to start the development of *Blue Streak* as a missile and to stop it, the conditions of Anglo-American co-operation and his reply to Lord Shackleton on space research. Lord Hailsham said that we are now spending about 8 per cent of our gross national product on foreign aid or on defence, compared with 11 per cent by the United States. The question of space research, he said, should be approached with great caution, as we must be selective in what novel technologies we can develop, and if *Blue Streak* is to be developed for that purpose it would be a first consideration whether this might not be a co-operative enterprise. The decision to undertake space research, however, must be based on careful appreciation of the scientific and technological factors involved, and while Lord Hailsham agreed that space research may have important secondary effects on the rate of progress in such fields as electronics, metallurgy and telecommunications, Lord Hailsham was clearly averse to making any switch in our fully extended scientific effort without due forethought.

The harmonious working of the present system of defence research and development in Britain depends largely on the tact, efficiency and self-effacement of the staff of the Ministry of Defence. They create, indeed, an atmosphere and tradition for successful inter-Service negotiation and co-operation. What is clearly also required is something of the same atmosphere and tradition between defence and civil research, such as Sir Henry Tizard was so successful

in inspiring. The Minister for Science has undoubtedly a large part to play, and the Government's ultimate decisions regarding *Blue Streak* and space research may well indicate also how effective the arrangements for co-ordinating civil and defence research and development are likely to be, now that the new Ministry has been established, and whether it is not imperative to re-examine urgently the functioning and relations of both the Defence Research Policy Committee and the Advisory Council on Scientific Policy. If the debates on the White Paper on Defence, on the Service Estimates and on the *Blue Streak* missile have done nothing else, they have demonstrated the need for informed and impartial discussion, especially in scientific and technical circles; and at the same time they have shown up the absence of much of the information upon which any such discussion must be based if it is to be worth while.

CONTROL OF SCIENTIFIC RESEARCH IN THE UNITED STATES

Science and State Government

A Study of the Scientific Activities of State Government Agencies in Six States. By Dr. Frederic N. Cleaveland. Pp. xvi+161. (Chapel Hill, N.C.: University of North Carolina Press; London: Oxford University Press, 1959. Published for the Institute for Research in Social Science.) 3.50 dollars; 28*s*. net.

To some extent, Dr. Cleaveland's study of the scientific activities of State Government Agencies in the six States of California, Connecticut, New Mexico, New York, North Carolina and Wisconsin is a complement of D. K. Price's "Government and Science", which was concerned essentially with the scientific activities of the Federal Government and the interaction of science and public policy. Dr. Cleaveland scarcely enters into those larger issues. For the British reader his book lacks the outstanding interest of Mr. Price's study; however, some at least of the experience he surveys bears on problems encountered in Great Britain. There is no clear parallel in British experience to the State system, though strong pressure has at times been exerted for the establishment by the Department of Scientific and Industrial Research of local research stations for Scotland or Wales. The six States covered by this report are already expending £1–15 million a year on scientific activities as compared with an estimate for 1960–61 of some £12·7 million for the Department of Scientific and Industrial Research, £5 million for the Agricultural Research Council, £4 million for the Medical Research Council and more than £65 million for universities and colleges, etc.

No local scientific expenditure of such magnitude is to be found in Great Britain, and although these sums are small against the Federal Government expenditure on scientific activities of approaching £1,000 million, they raise, as Dr. Cleaveland shows, important problems of co-ordination and balance. There are, for example, considerable variations in the expenditure in particular fields as between the six States: in agriculture it varied from a fifth to two-thirds of the State expenditure in that field, whereas in health, education and welfare it was usually less than 0·5 per cent, and only as much as 1 per cent in one State. In the development of resources and public works, it was 1 per cent or less in four of the States, but in the semi-arid States of California and New Mexico, with major problems of physical resources and significant mineral resources the figure was 1·7 and 2·8 per cent, respectively. Again, four States invested 3–4 per cent of the total expenditure on the State university in scientific activities, chiefly research, and in Wisconsin and in California this figure ran to 5·8 and 8·5 per cent, respectively, probably because of the extent to which these two States rely upon their universities for the provision of major research activities. In California, indeed, more than 92 per cent of the expenditure on scientific activities was on research, compared with 70–77·5 per cent in the remaining States. Expenditure on basic research in 1954 varied from less than 0·5 million dollars in New Mexico to 10·5 million dollars in California, or 16 per cent and 39·5 per cent of the budget for scientific activity compared with 25–33 per cent in the remaining four States, and some 40–50 per cent on applied research (70 per cent in New Mexico and 60 per cent in California). The study also indicated that State research efforts are heavily weighted in the direction of the biological sciences, physical sciences receiving only 20–30 per cent of research funds in four of the States, only 5 per cent in New York but nearly 50 per cent in New Mexico, compared with 87 per cent from the Federal Government's research and development expenditure.

There was some State expenditure on related scientific activities, such as scientific information, the training of scientific man-power and the planning and administration of research, and Dr. Cleaveland found that the allocation of scientific man-power was in accordance with the picture of scientific activity provided by the analysis of expenditure, and his analysis of the role of the State university suggests that in some measure the idea of a regional university has found favour. Problems of administration, inter-government relations and the position of the scientist under the State Governments are also discussed, and in his concluding chapter Dr. Cleaveland presents his conclusions and points to certain weaknesses revealed by his study. As might be expected, one is a lack of balance in scientific activity, and another the limited use made of research as a means of aiding policy. Nevertheless, he suggests that scientific activity at the State-level is already assisting the practice of State Government in various ways, but it would appear that for the more effective utilization of scientific as well as national resources further assistance from Federal institutions such as the National Science Foundation, which has issued its own report on this survey, is needed. Of particular interest also is the picture given of the State universities and the pattern of their dependence on Federal and on State support; but the issues involved are not really discussed though they will largely determine the success or failure of the present effort to expand scientific and technological education in the United States. To the British reader some such examination of the factual data assembled in this survey would have been welcome, especially as here and there Dr. Cleaveland shows that he is fully competent to make such an appraisal.

R. Brightman

METALLIC CORROSION

The Corrosion and Oxidation of Metals

Scientific Principles and Practical Applications. By Dr. Ulick R. Evans. Pp. xi+1094. (London: Edward Arnold (Publishers), Ltd., 1960.) £4 40s. net.

IT is largely owing to the work and teaching of Dr. Ulick Evans that the subject of metallic corrosion and protection can properly be said to have achieved scientific status. Although, as he is careful to point out in another book, extensive studies of the subject were being made at a number of laboratories at the turn of this century, it was not until his group at Cambridge began its work in 1923 that the electrochemical basis of wet corrosion became firmly established. Since that time, no one concerned with either the causes or the results of corrosion could afford to ignore the prodigious amount of first-class fundamental work accomplished by Dr. Evans and his school. Nor could they safely ignore the successive editions of his book "Metallic Corrosion, Passivity and Protection" which have so lucidly marshalled the facts and theories relating to this important subject and always with copious references to the current scientific literature. Many students, too, will be familiar with his shorter version "An Introduction to Metallic Corrosion", which has formed the basis (and sometimes the totality) of their college corrosion lectures.

Dr. Evans' new book is completely up to date. It contains references to some 6,500 published papers, a high proportion of them appearing since 1950 and some of these as recently as the early months of 1959. For some readers it will, therefore, serve chiefly as an up-to-date book of sources, which are now incidentally grouped at the ends of relevant paragraphs and chapters, together with much useful commentary. The inevitable selection which has gone to produce even this enormous number of references is in many ways beneficial, for we are left with only that work which the author deems to have been of importance in forming his views or which presents stimulating or conflicting data and theories. For many, however, the chief advantage of the book lies in the arrangement of the material. Very little of the pattern—or, indeed, the matter—of earlier books remains. Instead, the twenty-two chapters have been so written as to be self-contained, and each is prefaced by an excellent synopsis which, besides summarizing its contents, relates it to other parts of the book.

The first chapter is in the nature of an apologia and demonstrates the importance of an understanding of the subject for engineers, architects, economists and public health authorities as well as for many pure scientists. In the next seventeen chapters (756 pp.), the author gives us his personal views on the qualitative aspects of corrosion, oxidation and protection. Included in this section is a new chapter on what he describes as 'crystallographic' corrosion, that is the way in which surface features on an atomic scale influence the mode and distribution of metal dissolution. Then he gives us four chapters (184 pp.) in which the quantitative aspects are discussed in more detail, together with the laboratory measurements upon which these are based. Finally, there are two appendixes, which, in the incredibly short span of 91 pages, provide a concentrated course in chemistry, electrochemistry and electrokinetics. Although showing signs of hasty preparation, being marred by several misprints, these appendixes should prove of enormous help in providing the necessary scientific background for the 'non-technical' reader; and at least one electrochemist found them to constitute rather more than a refresher course. Perhaps, however, we could have had a little more about exchange currents and the differences between the hydrogen and oxygen reactions in this respect, in view of their important bearing on over-potential in corrosion and electroplating systems.

As well as re-arranging his material, the author has slightly expanded it (what was 800 pages in the 1948 edition of "Metallic Corrosion, Passivity and Protection" is now 940 pages), in particular as regards the conjoint action of stress and corrosion, hydrogen cracking and the corrosion of buried metals. Four chapters are devoted to oxidation, six to electrochemical corrosion, three to a consideration of practical environments (for example, boilers), three to conjoint effects (stress-corrosion, corrosion fatigue and fretting corrosion), three to corrosion protection (coatings and inhibitors) and there are two chapters on testing methods and the statistical treatment of data.

One could not wish for a more comprehensive or well-written book, and, despite the threefold increase in price since "Metallic Corrosion, Passivity and Protection" in 1948, there can be no doubt that it constitutes a 'must' for anyone hoping to keep abreast of corrosion science and practice.

J. M. West

PROGRESS IN NUCLEAR SCIENCE

Annual Review of Nuclear Science

Vol. 9. Edited by Emilio Segrè and Leonard I. Schiff, in association with Gerhart Friedlander and Walter E. Meyerhof. Pp. vii+625. (Palo Alto, Calif.: Annual Reviews, Inc., 1959. Published in co-operation with the National Research Council of the National Academy of Sciences.) 7 dollars.

THE ninth volume of this series maintains the high standard set in previous years. Wilkinson reviews the recent, and on the whole satisfactory, developments in the theoretical interpretation of nuclear photodisintegration experiments. The high-energy field is again prominent. Chew contributes a clear and concise discussion of the recent field theoretical approach to pion-nucleon interactions through dispersion relations and 'pology'. This is a difficult subject but of great importance for the understanding of high-energy interactions. High-energy nuclear reactions are discussed by Miller and Hudis. This embraces spallation, fragmentation and fission at 100 MeV. or more and includes a detailed compilation. Okun' (Moscow) discusses the weak interactions, that is the decay properties of the new strange particles. This is the portion of high-energy physics which is changing most rapidly. Konopinski contributes a most useful review of β-decay theory which is timely now that the violation of parity 'revolution' is complete. It complements Okun's article admirably.

Four reviews of very general interest are nuclear fission by Halpern, nuclear electronics by Kendall, plasma and fusion research by Post and fast reactors by Koch and Paxton. In all these subjects many interesting developments can be reported. An article

on the economics of nuclear power by Lane is unfortunately only pertinent to the United States and so is of limited interest.

Two chemical contributions, technetium and astatine chemistry by Anders and solvent extraction by Freiser and Morrison record facts and techniques hitherto scattered through project reports. Three radiobiological articles as usual complete the volume: vertebrate radiobiology (embryology) by Rugh, biochemical effects of radiation by Ord and Stocken, and cellular radiobiology by Atwood. These demonstrate the continuing advance in this broad field.

E. B. PAUL

MASS, LENGTH AND TIME

An Introduction to the Physics of Mass, Length and Time

By Prof. Norman Feather. (Science and Mathematics Texts, No. 1.) Pp. ix+358. (Edinburgh: At the University Press, 1959. Distributed by Thomas Nelson and Sons, Ltd.) 18*s*. net.

THE early part of this excellent book deals with the history and philosophy of fundamental measurement, together with the practical problems of defining, preserving and reproducing standards. It is a fascinating story, told with scholarship and skill. The rest presents the usual matter of a course of Advanced Level General Certificate of Education standard in mechanics and general physics in an unpretentious and thoughtfully penetrating way.

Prof. Feather has, as he puts it, "disdained to use the calculus". This is not really hauteur, but a means of enforcing a pace of slow and careful reading; the modern student is all too fluent, and can use it slickly without thinking. At the same time, it can be argued that the moment you introduce the concepts of velocity and acceleration, draw a continuous graph, or use moment of inertia or impulse, you are really using the calculus, though not its notation. You do not remove the tune from a piece of music by writing it in tonic sol-fa. The author does unbend a little in the last chapter, in fact. But if he had not himself directed attention to this point specially, it would not have called for comment.

Newtonian mechanics, and what John Cox called "the winning of the principles", are clearly explained, with emphasis on the importance of the third law. A whole chapter is devoted to potential energy, which is really a much deeper matter than the usual elementary books suggest. Gravitation is treated historically, starting with the genesis of Newton's law and ending with the design problems of apparatus of the type devised by Cavendish. For the rest, the discussion of the struggles of Archimedes with the law of the lever, and that of surface tension in terms of interfacial energy and molecular attraction, are among the many stimulating treatments.

The general outlook of the book is more like that of "Norman Campbell" or "Pearson" or "Pohl" than that of the ordinary text-book, though teachers of sixth-form physics would do well to consider its possibilities for class use, and it would certainly be a valuable book for students to read. It puts the inquiring approach of the scientist before the factual knowledge of the examinee. The liveliness and effortless dry humour, fortified by a wealth of historical detail, make it very pleasant to read, and the publishers have produced it most attractively.

G. R. NOAKES

SPOTTING KETOSTEROIDS

Oxosteroids

The Use of Phenolic Hydrazides for Detection, Characterization and Estimation. By Bernard Camber. Pp. viii+79. (London: H. K. Lewis and Co., Ltd., 1960.) 12*s*. 6*d*. net.

WHAT we used to call 'ketosteroids' can usually be estimated by some modification of the Zimmerman reaction, and the colours given by different ketosteroids with alkali and *m*-dinitrobenzene have long been used in 'spotting' on paper chromatograms and in the test-tube as a rough guide to the position of the keto group in the steroid molecule in unidentified substances.

Dr. Camber is a medically trained man with an interest in chemistry. His little book is an account of his search to find a hydrazine derivative which would condense with known physiologically important ketosteroids to give hydrazones which could be used to provide a quantitative method replacing the Zimmerman procedure, to identify individual ketosteroids as spots after chromatography on paper and in the histology of steroid-containing tissue. After forty-one pages, he arrives at salicyclic acid hydrazide (salicoyl hydrazine), which readily gives, with ketosteroids, hydrazones that can be used for these purposes. The early part of the book has a short account of some methods used for steroid estimations and also details of Dr. Camber's less-useful derivatives of hydrazine. His finally chosen reagent is valuable, although the quantitative methods have not received exhaustive testing with urines and only preliminary histological work has been done. 'Spotting' on paper chromatograms is, however, well developed, giving useful information about steroids separated. The author is an ingenious experimenter, as is shown, for example, by his technique of spot testing in 'Cellophane'. It is also clear that he has enjoyed doing and expounding his work. He is perfectly frank in not pretending that his reagent is perfect for the purposes suggested: he gives details and obviously would prefer those interested to try it for themselves.

Workers in this field will be willing to buy this book for the 'know-how' which it contains. Full experimental details are given for all methods, qualitative and quantitative, recommended, including the preparation of a sufficiently pure sample of salicyclic acid hydrazide.

G. A. D. HASLEWOOD

STUDIES IN MARINE PHYSICS

The Gulf Stream

A Physical and Dynamical Description. By Henry Stommel. Pp. xiii+202. (Berkeley and Los Angeles: University of California Press; London: Cambridge University Press, 1958.) 45*s*. net.

IN Europe, at least, marine biologists vastly outnumber marine physicists, and one of the things that has prevented physicists from becoming interested in the oceans is the difficulty of finding concise accounts of the problems written in the precise terms to which they are accustomed when dealing with modern science. Dr. Stommel is one of the leaders of a strong theoretical group in the eastern United States, who has spent many years studying the Gulf Stream, and his book gives a clear and

comprehensive account of the present state of knowledge. In the North Atlantic Ocean, as in the other main oceans, an anticyclonic wind system produces a current system in the same sense, and the main problem is that if the wind system, which is a broad widespread phenomenon, drives the ocean currents, why is the current system so asymmetrical with its strongest currents squeezed into a narrow strip on the western side of the Ocean ?

The simplest explanation involves consideration of the forces due to the Earth's rotation, and the fact that a steady state cannot be reached until the angular momentum added to the water by the wind is balanced by the changes in vorticity which occur as the water moves north or south into parts of the Earth that have different angular rotation. The wind introduces a clockwise spin, the movement of water northwards from an area of the Earth with less anticlockwise spin to one of more anticlockwise spin increases its own clockwise momentum relative to the Earth. To balance such an effect, the simplest theory suggests that there are frictional forces generated in a thin poleward-flowing current in the western marginal region. An alternative theory due to Charney replaces the 'frictional' layer by an inertial boundary layer.

Dr. Stommel gives detailed descriptions of the mathematical models expressing these theories, and shows that the current is really a flow along the boundary between masses of cold and warm water, so that it might be better to study the origin and nature of these two water masses and to treat the current as a secondary feature. This leads him to a tentative new theory of the circulation likely to be caused by differences of temperature and salinity between one part of the Ocean and another, and to a stimulating and critical review of the whole state of our knowledge of the physical processes. He does not belittle the survey type of oceanography, nor theoretical speculation, but makes a strong plea that more attention be given to the difficult middle ground, the testing of hypotheses. This sets the pattern of his book ; he gives a fine historical introduction, an account of the methods used to study the current, a summary of what we know about the properties of the water, velocities and seasonal changes, and does everything possible to test the various ideas that have been put forward. To-day a great deal of effort of the kind he has long advocated is being devoted to the study of the Gulf Stream, and although it must add to what he has written it will not reduce the value of the book. G. E. R. Deacon

THE TWO R's OF PLANT BREEDING

Abstract Bibliography of Fruit Breeding and Genetics to 1955

Rubus and *Ribes*—a Survey. By Dr. R. L. Knight and Elizabeth Keep. (Technical Communication No. 25 of the Commonwealth Bureau of Horticulture and Plantation Crops.) Pp. iii+254. (Farnham Royal : Commonwealth Agricultural Bureaux, 1958.) 45*s*. ; 6.80 dollars.

DR. R. L. KNIGHT, in charge of raspberry and currant breeding at East Malling since 1954, and Miss E. Keep have built up a useful abstracted bibliography on *Ribes* and *Rubus*. For the specialist such a work needs not only to be complete, but also the abstracts, particularly of papers in foreign languages and in obscure journals, must be sufficiently detailed to be of value. The authors have only partially succeeded in this last respect. The bibliography is incomplete, and several recent important papers by British authors on the cytology and genetics of British forms of *Rubus* are unfortunately listed by title only. Some of the individual abstracts are good, for example, the salient features of the 76-page paper of Fassett on mass collections are condensed into ten lines. Some other abstracts appear to be condensations of earlier abstracts, and one wonders if these have been verified : for example, work by Dowrick is wrongly attributed to LaCour. Bibliographical errors are few : Zinno should read Jinno.

One disadvantage of a bibliography is that a newcomer is not readily able to assess the relative merits of the individual papers, and here the compilers have not helped. Although some papers, such as Spinks's on black currant breeding at Long Ashton, are fully abstracted, the length of an abstract provides little indication of a paper's scientific merits. This book would, therefore, have benefited from sieving. Some of the now worthless earlier papers could have been omitted, and the space used to provide the authors' comments on the more important ones.

A most unfortunate decision has been to mix the references of *Ribes* with *Rubus*. Two separate bibliographies with their own indices would have been an advantage, especially when surveying previous work on each genus, and in using the subject index.

Two appendixes are provided. That of a gene list for *Rubus* concerns only raspberry, but several genes are known in blackberry ; it is perhaps unfortunate that the symbol *A* is given to *Amphorophora* resistance, as this had already been assigned to autumn flowering (not listed). Appendix II gives two linkage groups, of especial interest for until now it had seemed that all the tested genes in *Rubus* lie on one chromosome, and the remaining six chromosomes were possibly inert. No gene list is given for *Ribes*, although data are available in the omitted "Genetics of Garden Plants" (Crane and Lawrence). No list of chromosome numbers is provided, which would have been useful as there is no reference to Darlington and Wylie's "Chromosome Atlas".

A graph, calculated from the bibliography, clearly shows that breeders have been, and will be, more interested in raspberries, blackberries and kindred fruits, than in gooseberries and currants. Indeed, research with *Rubus* now considerably outstrips that for *Ribes*. This is partly because *Rubus* affords more genetically versatile experimental material, and partly from lack of interest in *Ribes* in North America, where *Ribes* cultivation is banned. Yet the considerable demand for black currant juice abroad provides the basis for the present policy at Mylnefield to breed high-yielding, uniform, early ripening varieties, to increase the acreage in the soft-fruit areas of the East of Scotland.

This expensive bibliography was already three years out of date when it went to press. Hence important new works like Watson's monograph on British forms of *Rubus* are not included. The publishers and authors might consider, therefore, issuing to purchasers a free mimeographed supplement bringing the list up to date. Generally this compilation will save time, but it is hoped that those who use it will not by-pass the originals, unless we may conclude that nowadays only summaries really need be published. G. Haskell

I.G.Y.

Year of Discovery—The Story of the International Geophysical Year. By Sydney Chapman. Pp. 112. (Ann Arbor : University of Michigan Press ; London : The Mayflower Publishing Co., Ltd., 1959.) 40*s.* ; 4.95 dollars.

THE International Geophysical Year, July 1, 1957–December 31, 1958, was the most successful example of co-operation between the nations there has ever been, and as well as being a landmark in the development of geophysics it may well be of significance in the present endeavours to increase international understanding. In his account of this enterprise, of the executive committee of which he was president, Prof. Sydney Chapman records how at first there was little enthusiasm for a successor to the two international polar years and then how the interest grew until International Geophysical Year committees from sixty-seven countries joined in and a wide variety of geophysical projects were undertaken, to be climaxed by the launching of the first Earth satellite on October 4, 1957.

But the book is not an account of the organization of the International Geophysical Year, important though this was. It is an excellent account of the scientific background of and the reasons for the projects undertaken.

Those familiar with Prof. Chapman's writings will not be surprised to know that this book is a model of scientific writing ; the sentences are short and not encumbered by unnecessary words ; a large number of useful facts about the Earth are to be found in the text ; plates and diagrams illustrating the whole field of activity are included. It can therefore be recommended to students and to laymen who wish to acquaint themselves with what is known about the Earth, and there will be few, even among experts in geophysics, who will not learn something by reading it.

S. K. RUNCORN

Progress in Semiconductors, Vol. 4

Edited by Dr. Alan F. Gibson, Prof. R. E. Burgess and Dr. F. A. Kröger. Pp. vii+291. (London : Heywood and Co., Ltd., 1960.) 63*s.* net.

THE series of review articles which make up the volumes of "Progress in Semiconductors" help very much to cut down the time which physicists, chemists, metallurgists and electronic engineers in this still rapidly expanding field have to spend reading the journals less familiar to them. Unfortunately the series can survey the whole field no more frequently than perhaps once every ten years.

The eight papers which make up the fourth volume are generally well written but expect quite a lot from the reader. The easiest to read are those on the oxidation of germanium surfaces (the Mott–Cabrera mechanism is ruled out for a clean surface), on internal field emission, which has been studied in *pn* junctions and in phosphors, and on the electrical effects of dislocations. In contrast a paper on negative mass demands some familiarity with quantum mechanics and another on avalanche multiplication demands confidence in expressions for the motion and scattering of electrons in high fields. A paper on noise in semiconductors shows that the components with spectral intensity $\propto$ (frequency)$^{-1}$ still need further study. The effect of dislocations on dielectric properties is studied in another paper in terms of ion movements, electron trapping and microwave observations. The last paper, of which A. F. Ioffe is co-author, directs attention to a large range of non-crystalline semiconductors, including liquids, in which the carrier motion is very different from that in germanium and silicon.

J. R. TILLMAN

Comprehensive Inorganic Chemistry

Edited by Prof. M. Cannon Sneed and Prof. Robert C. Brasted. Vol. 7 : The Elements and Compounds of Group IVA. By Harold P. Klug and Prof. Robert C. Brasted. Pp. ix+302. (Princeton, N.J. : D. Van Nostrand Company, Inc. ; London : D. Van Nostrand Company, Ltd., 1958.) 56*s.* 6*d.*

THIS book is one of a series in which an attempt has been made to combine an encyclopædic treatment of the chemistry of the elements with the inculcation of the basic principles of chemistry. When one considers the extent and complexity of inorganic chemistry to-day, it is clear that a good deal of information must necessarily be omitted if a whole group is to be covered in a volume of this size. For example, the historical background of each element is cut to a minimum (but Cornish tin (page 212) certainly reached Rome before the Roman conquest of Britain), and it is, perhaps, a little surprising that the uses of carbon-14 are scarcely mentioned and, in view of their uses in atomic energy, some reference might well have been made to cadmium and cerium glasses. However, the descriptive chemistry of the elements covered in this volume is presented lucidly and the result is a not unpleasing text-book which should be useful to the university student and to the research chemist, for whom the numerous tables of physical data will be of considerable value. The book is well produced, and the index, so far as tested, is adequate.

K. W. BAGNALL

Histochemistry

Theoretical and Applied. By A. G. Everson Pearse. Second edition. Pp. x+998+10 plates. (London : J. and A. Churchill, Ltd., 1960.) 110*s.* net.

THIS is a vast guide-book to the fields of histochemistry. Twenty-nine chapters and twenty-seven appendixes provide a comprehensive and up-to-date account of the subject. In the spirit of "Baedecker" the author has practised all the available methods and rejected those found wanting. This enormously enhances the value of the book, but had the further step of a star system been taken to classify the many methods, the novice would be better served. There have been so many improvements and extensions since the first edition of seven years ago that this is virtually a new and better book.

The chemical and physical backgrounds to the techniques have been given so far as is practicable in a book of finite size. Readers with special knowledge of the various aspects of the subject will no doubt find omissions, misunderstandings and misplaced emphasis, but I have found no serious cases in my own special fields. With this volume as a guide, cytochemists can travel hopefully but might be more sure that they would arrive safely if an extended and quantitative account of the hazards and errors of interpretation due to diffusion during fixation and reaction had been provided. The illustrations, especially the colour plates, make this an attractive book to use, but have undoubtedly added to its high cost. Inexcusably the book is shoddily cased, and with a covering unlikely to withstand the hard use this book will undoubtedly have in all histochemical laboratories.

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THE MARANGONI EFFECTS

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Cause of, and Resistance to, Surface Movements

WITH the name of the Italian physicist Carlo Marangoni of Pavia and Florence (1840–1925) have been associated two distinct although related surface effects. The first of these is movement in a fluid interface. The motion is caused by local variations of interfacial tension that are caused in turn by differences in composition or temperature. The second is the conjugate of the first : it is the departure from equilibrium tension that is produced by extension or contraction of an interface, that is, by dilational deformation. Both effects were correctly explained in a qualitative way nearly a hundred years ago. A wealth of information about them was reported by Marangoni and his contemporaries, among whom were some of the foremost scientists of the nineteenth century—Plateau, Gibbs, and Rayleigh.

Certain aspects of surface spreading and dynamic surface tension have continued to receive attention in the physical chemistry of fluid interfaces, especially as that subject pertains to foams and emulsions. However, little effort has been directed toward quantitative understanding of these effects as they affect the dynamic behaviour of fluid interfaces. To-day there is heightened interest in this goal, because of the growing number of diverse, practically important situations in which their influence is being recognized. For example, it is now known that local variations of surface tension may set into intricate motion an entire liquid film such as a drying coat of paint. Again, it is now appreciated that the difference between dynamic and equilibrium behaviour of interfaces is responsible for the paradoxical motion under buoyancy of small bubbles and drops in various liquids.

Surface Movements

"On Certain Curious Motions Observable at the Surfaces of Wine and other Alcoholic Liquors", published in 1855 by the British engineer and physicist James Thomson[1], contains the first correct explanation of the spreading of a drop of alcohol on the surface of water, the well-known tears of strong wine, and related phenomena. Thomson rightly inferred that the same sort of surface-tension-driven flows were responsible for the "numerous motions of extremely wonderful characters in fluids undergoing evaporation" that Varley had observed earlier with the aid of a microscope[2]. Similar microscopic studies of convection patterns in evaporating drops were made independently by Weber[3].

Numerous fascinating experiments with surface movements were reported afterwards[4–7] ; but Thomson's paper went unnoticed until van der Mensbrugghe's definitive memoir appeared in 1869 in a now obscure Belgian journal[8]. Van der Mensbrugghe reviewed all the earlier work, including the literature on the camphor dance dating back to 1686, and established that all the varied instances of surface movement were caused by local differences of interfacial tension. When Marangoni contested the priority of van der Mensbrugghe's finding[9], Thomson's paper again went unmentioned, and it is probably for this reason that the effect has come to bear Marangoni's name (cf. ref. 10).

The classic qualitative studies have been continued by more recent investigators : Marcelin devised surface engines[11], Loewenthal was fascinated by tears of strong wine[12], the Langmuirs discovered that surface movements enhance the rate of evaporation[13], and Jebsen-Marwedel found that surface-tension-driven flows critically affect mixing and wall erosion in glass-melting furnaces[14,15]. Photographs of tears of strong wine have recently appeared[16]. There have been discussions of the role of such flows in crystal growth[17,18], motion of protoplasm[19–21], transport of bacteria[21], surface fractionation[22], absorption and distillation[23], foam stability[24,25] and other phenomena[26,27]. Mention should be made of the thermodynamic theories of spreading of surface films[28].

The cellular convection patterns induced by surface tension that Varley[2] and others[3,19] saw were later the subject of Bénard's beautiful experiments[29,30]. Bénard's work inspired the Rayleigh–Jeffreys theory of convection currents induced by density variations in liquids heated from below. However, this theory is at variance with Bénard's experiments in several respects. From the new experiments of Block[31] and theoretical analysis of Pearson[32] it is now known that surface tension rather than density variations produced Bénard's cells. Meanwhile the Rayleigh–Jeffreys theory has been confirmed by other experiments to which it properly applies[33]. It is interesting that Sutherland was led to postulate density-induced convection currents in order to explain the surprisingly rapid attainment of equilibrium tension at certain newly formed gas-liquid interfaces[34]. Surface-tension-driven flows seem no less likely an explanation.

The periodic twitching of an air bubble in water, toward which a fine jet of alcohol is directed, seems to have been first described by Quincke[18], who showed that surface-tension-driven flow is responsible. Recently rediscovered in slightly different guise by Lewis and Pratt[35], the phenomenon has attracted great interest in the field of liquid-liquid extraction. A semi-quantitative theoretical analysis was made by Haydon and Davies[36,37]. Similar phenomena occur at all sorts of fluid interfaces across which material diffuses[38,39]. Notable is the extensive investigation by Wei[40]. This spontaneous agitation of the interface between two unequilibrated fluids, which has come to

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be known as 'interfacial turbulence', has not yet been taken into account in the classic theories of interphase mass transfer. In order to arrive at an adequate theory, it will be necessary to know precisely the conditions which give rise to interfacial turbulence as well as the details of the flows. We have considered the preliminary problem from the point of view of the theory of hydrodynamic stability, arriving at a partial understanding of the factors that determine 'Marangoni instability'—the onset of interfacial agitation driven by local variations of interfacial tension[42].

Our analysis shows how it is that some systems are stable with solute transfer in one direction across the interface yet unstable with transfer in the opposite direction (cf. ref. 42). It indicates the importance of solute diffusivity in the two phases, the viscosities of the fluids, the dependence of interfacial tension on composition, and other parameters. In at least some circumstances the phenomenon known as spontaneous emulsification seems to originate in interfacial-tension-driven flows[43].

Surface Elasticity and Viscosity

The resistance of a fluid interface to deformation was first noted by the blind Belgian physicist Joseph Plateau, famous for his researches on capillary action, especially the equilibrium configurations of liquid masses under the influence of surface tension (see his great treatise[44]). The different rates of damping of an oscillating compass needle suspended on one hand in the surface and on the other in the bulk of various liquids led Plateau to infer the existence of a 'superficial viscosity' peculiar to a liquid surface but analogous to the ordinary viscosity of fluids in bulk[44,45]. In so far as his needle subjected the surface to shear, Plateau's inference was substantially correct: since his time, measurements of shear viscosity and elasticity of surface films have become commonplace[28,46–51]. However, if surfaces of pure liquids have a peculiar resistance to shear, present experimental techniques are not sufficiently sensitive to detect it.

What Plateau did not appreciate is that virtually every liquid surface is contaminated with insoluble material to some degree, and that there exists an equilibrium between material dissolved in the bulk and adsorbed on the surface of solutions. Thus the advancing needle tended to concentrate contamination and adsorbed material ahead and to dilute them behind it. This produced a difference in surface tension on either side of the needle, the difference being of the proper sense to damp the motion.

Marangoni[52] first clearly recognized this effect in the experiments of Plateau, who remained unconvinced[53–55]. It remained for Gibbs to give it a completely satisfactory explanation[56]; hence the name, 'Plateau–Marangoni–Gibbs effect'[57]. There is a lucid and definitive paper on the subject by Lord Rayleigh[58], who made other valuable contributions to the understanding of surface movements and the resistance thereto[58–61]. The part played by the 'Plateau–Marangoni–Gibbs effect' in stabilizing free films and foams has long been recognized in a general way, often under the name 'Gibbs elasticity' (for example, ref. 25). But the "profound analysis of the act of thinning of a film" called for by Derjaguin and Titijevskaya[57] has not yet appeared. The mathematics of such an analysis is formidable, owing to the complicated velocity and concentration fields involved.

As Birkhoff observed in connexion with the 'rising-bubble paradox', the mechanics of real fluid interfaces is far less simple than the classical hydrodynamic treatments would suggest[62]. The paradox is that the motion under buoyancy of small bubbles and drops through a liquid is usually much closer to the behaviour of rigid spheres than to that expected for fluid spheres capable of internal circulation. But in systems cleansed of interfacially active material, the paradoxial behaviour does not occur, except with the smallest of bubbles and drops[63,64]. The seeming exception may be due to the extreme difficulty of eliminating the last traces of interfacial contamination[6,46,56,58,66]. If circulation of the bubble or drop is retarded or arrested, there must exist a force not contained in classical hydrodynamics which opposes the viscous traction exerted on its surface by the surrounding liquid; and because the viscous traction tends to expand the surface phase over the leading hemisphere and contract it behind, the 'Plateau–Marangoni–Gibbs effect' is sufficient to account for the existence of this force. The first to recognize this was Boussinesq[67], who showed that any viscous-like resistance to dilational deformation of the surface, whatever its origin, causes fluid spheres to move more slowly than expected from classical treatments, in which the possibility had been overlooked. Modern mathematical analyses have shown how the kinetics of adsorption of soluble surface-active materials can account for a 'dilational surface viscosity'[68,69]. The Marangoni effect mentioned above may also enter; for with mass transfer between the dispersed and continuous fluids, as occurs in liquid-liquid extraction and related operations, there may be a sufficiently high concentration—hence also interfacial tension—gradient in the proper direction along the interface to arrest or even reverse the internal circulation. The entire situation of drop circulation and the effects of surface-active materials was recently discussed by Linton and Sutherland[70].

The role of shear viscosity and elasticity of surface phases and of the 'Plateau–Marangoni–Gibbs effect' in other free boundary flows has been considered by at least a few hydrodynamicists after Aitken's discussion of the calming action of oil on capillary waves on the surface of water[71]. Specific reference should be made to the writings of Lamb[72], Levich (as cited by Fedosov[69]), and especially Oldroyd[73], whose theoretical work on the effect of surface properties in the rheological behaviour of emulsions is partly confirmed by the recent experiments of Nawab and Mason on the viscosity of dilute emulsions containing surfactants[74].

The resistance of fluid interfaces to deformation is manifest, though not yet completely understood, in the stagnation of portions of interfaces in certain liquid-liquid extraction[35,41,73] gas absorption[76], and vacuum distillation experiments[65,66].

Quantitative understanding of the dynamic behaviour of fluid interfaces requires that their mechanics be described mathematically. The earliest attempts at this seem to have been made by Tait, who considered the effect of flexural-rigidity of a surface on ripples in a viscous fluid[77], and by Basset, who examined certain consequences of interfacial behaviour that allows slip between two phases in contact[78]. The most useful description for approximating the behaviour of real interfaces is that begun

by Boussinesq, who set up the two-dimensional analogue of the three-dimensional Newtonian fluid[67]. In this model the mechanics of the interface is completely characterized by its static (equilibrium) tension and two coefficients governing its behaviour in flow: the surface shear viscosity and the dilational surface viscosity.

It was this model that Boussinesq appealed to in his explanation of the rising-bubble paradox. Only recently was it used in treating another free boundary flow, by Oldroyd as mentioned above. Surface-active materials inhibit the transition of falling liquid films from smooth to wavy flow[79]. In a new analysis of this transition regarded as a hydrodynamic stability question, Barr-David and one of us have suggested how to account for this influence of surfactants: we adopted Boussinesq's model in formulating boundary conditions at the free surface of the film[80]. In order to account for a similar inhibitory influence of surface-active materials on interfacial turbulence, the same thing was done in our analysis of Marangoni instability[41].

In the original equations of Boussinesq and in their alternative statement as in Oldroyd's equation (4) [73], the model interface is constrained to shape and total extent both constant in time. While this restriction is reasonable for free boundaries in steady flows, or when the interfacial tension is sufficiently high, it is violated in many real situations. Consequently we have generalized Boussinesq's equations so as to describe the dynamics of a Newtonian fluid interface undergoing continuous change in shape and extent[81]. The analysis leads to the interfacial boundary conditions on non-steady flows with free boundaries. Also tabulated are boundary conditions for the relatively simple cases of planar, cylindrical, and spherical surfaces. The work of Oldroyd suggests the possibility of further extensions to describe interfaces displaying all types of linear visco-elastic behaviour, many of which have, in fact, been observed in the laboratory[17,25,28,50].

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PART-TIME COURSES IN FURTHER EDUCATION

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THE correctness of the comment in *Nature* of February 6 on the Crowther Report is shown by the attitude of both the Government and the Opposition in their discussions. Too little attention has been paid by the Committee to the problems of day release teaching and student difficulties in technical colleges, nor has this been related to the secondary modern school leaver. *Nature* rightly suggests that little consideration has been given to the lower streams of the secondary modern school.

A recent survey (which it is hoped will be published in detail later this year) supports the view that there are a number of students who will not benefit by any form of further education. Table 1 gives the percentage pass mark of a first-year intake studying eventually for the Radio Trades Board's examinations. The examination was on calculations taught in a 24-hr. course of basic arithmetic and algebra. When studied with the corresponding results of first-year intakes over the preceding three years a safe assumption is that those students scoring below 40 per cent in similar tests do not benefit from this type of education. Schedule *B* of Table 1 gives the practical marks for the same period. These are also typical of all the intakes, and there is not necessarily an increasing practical ability with the decline in marks gained in the theoretical examinations. Inquiries made at other technical colleges confirm this view. However, these inquiries also suggest a further subdivision in the classification of apprentices. This is referred to in items 3*a* and 3*b* of Table 2. The results of this particular survey indicate that it is impossible to classify the rejects from 3*a* as students who would have benefited by following a course of studies more appropriate to 3*b*. There are a large number of persons in semi-technical occupations who do not benefit by further education. The fact that many students are quite obviously unsuited for the careers they have chosen is both the fault of the employer and the careers specialist in the school and may influence the mobility of labour more than would be anticipated.

However, studies of the teaching methods applied to groups 3*a* and 3*b* arising from an examination of the problems of wastage in group 3*a* suggests that entirely different approaches are required for the two groups and that those in group 3*a* would benefit from a year's full-time study of their subject. Group 3*b*, into which fall trades such as carpentry, plumbing, automobile engineering, apparently gain more from an apprenticeship with day release over a period of five years than do those in group 3*a* (for example, those students who pursue radio and television servicing courses), where the wastage over the first three years is large. Table 3 shows the decline in student attendance over the three years which is necessary for the Radio Servicing Certificate. The main causes of wastage are as follows: (1) insufficient ability to cope with studies; (2) refusal of the employer to allow more than one or two years part-time education; (3) change of occupation: (*a*) within the trade but to an employer who does not allow day release, (*b*) to employment in another trade; (4) completion of articles during the period of study; (5) decline of interest on the part of the student.

The wastage due to apparent low intelligence quotient was considerably reduced by changing the teaching methods from one year to the next. Following up in the third year with the improved methods of teaching did not, however, maintain the pass percentage, thereby supporting the view that there is a minimum level of intelligence quotient required for satisfactory attendance on this type of course. Further support for this view is gained from Table 1, where only one of the three students referred from the previous year to repeat the course passed the calculations examination.

Table 1. MARKS OBTAINED BY FIRST YEAR STUDENTS IN INTERNAL CALCULATIONS AND PRACTICAL EXAMINATIONS

Student	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*K*	*L*	*M*	*N*	*O*
Schedule *A*	84	77	73	70*	68	55	55	48	48	48	42	39*	37	27	*a*
Schedule *B*	60	70	70	60	50	50	40	40	50	60	50	50	40	30	
Schedule *C*	45	50	50	60	45	45	50	75	40	40	35	50	30	35	

* Students repeating the same year of studies; *a*, student absent but unlikely to pass examination on basis of previous marks.
Percentage pass = 42·8 per cent. Percentage pass on a simple average = 57 per cent.
Schedule *A*, calculations examination; schedule *B*, practical examination; schedule *C*, previous terms practical marks.

Table 2. CLASSIFICATION OF APPRENTICES COMPARED WITH THE LEVELS OF QUALIFICATION SUGGESTED IN THE CROWTHER REPORT

Schedule *A* Classification of apprenticeship	Schedule *B* Type of further education	Schedule *C* Levels of qualification for industry
(1) Graduate	Within industry Sandwich or part-time day	Technologist
(2) Student		Technologist Technician
(3) Trade:		
(*a*) Technician, for example, radio and electronic servicing	Part-time day or evening over 4 or 5 years	Craftsman
(*b*) Craftsman or artisan, for example, building plumbing		Craftsman
(4) Operative	Short period of industrial training	Operative

Table 3. ILLUSTRATION OF THE DECLINE IN ATTENDANCE OF PART-TIME DAY RELEASE STUDENTS OVER THE THREE YEAR PERIOD OF THE RADIO SERVICING COURSE

Course	First-year enrolment (per cent)	Per cent passing end of first-year test	Second-year enrolment (per cent)	Per cent passing intermediate certificate	Third-year enrolment (per cent)
A	100	36	36	36	18·1
B	100	42·1	31·5	21·05	21·05
C	100	20·0	20·0	continuing	

N.B. The percentages refer to the original first-year enrolment and thus to the same groups of students. They do not refer in later years to students entering the course with exemptions from previous parts of the course. Average number in each intake = 14.

Table 4. Illustration of the fact that it is Unlikely that there will be great Improvements in Attainment over a Lengthy Part-time Course

Table 4 gives the examination marks obtained by the same students at the same time of each year of the three-year radio servicing course

Student	*A*	*B*	*C*	*D*	*E*
First year	52	83	55	46	55
Second year	37	71	37	50	45
External exam.	P	P	P	P	P
Third year	40	70	48	40	48

P = Pass

The external examination was taken at the end of the second year. All internal examinations were marked by the same teacher.

Students are often unaware of their precise position in the trade. Many do not know whether they are on articles or not. Some commence the course in the middle of their indentures, and many towards the end of the three years question the value of the certificate in respect of the remuneration they will (or will not) gain by having the certificate. An important feature of the radio servicing course which has been studied is that practical ability does not increase with the number of years spent on apprenticeship, nor does it apparently help theory, which is an important feature since there are two written theory papers in the examination. A typical sample of marks gained by the same students over three years is given in Table 4. There is thus considerable support for the view that long part-time courses increase the wastage among students of this type of aptitude. The better approach would be to encourage employers to accept students for apprenticeship over a shorter period of time in order to allow them to attend a full-time course of further education before they commenced the apprenticeship, which would be for about two years, during which time they would continue with part-time education.

Table 5. Analysis of Part-time Evening Intake September 1959 Total intake, 63. 61 inquiries made. Wastage assessed for April 1, 1960

Student category	Percentage of total intake	Average age
(1) Students under 21, in trade	21·3	17·4
(2) Students under 21, in industry	21·3	17·8
(3) Students under 21, not in trade or industry	1·6	17·0
(4) Students over 21, in trade	19·6	—
(5) Students over 21, in industry	16·2	—
(6) Students over 21, not in trade or industry	20·0	—
(7) Total per cent of students with less than 50 per cent attendance	31·0	—
(8) Students under 21 with less than 50 per cent attendance	18·01	—

Finally, support for this idea is obtained from an analysis of wastage on evening courses. Table 5 gives the data for a first-year course enrolled in September 1959. The wastage at the time of writing is one-third of the total intake, but of the twenty-six students under twenty-one who are eligible for part-time day release free only seven have stopped attending, but studies of past wastage suggest that this figure will have doubled by the end of the second year. It seems clear that some form of test should be adopted with the view of establishing the worthwhileness of sending a boy on a part-time course in addition to Mr. Thompson's (*The Times*, April 3, Parliamentary Secretary to the Minister of Education) consideration that day-release should possibly become a legal right.

I am indebted to Mr. G. L. Danielson, head of the Department of Telecommunications Engineering, Norwood Technical College, for permission to publish some of the results of this survey.

SOCIETY OF GENERAL MICROBIOLOGY

MICROBIAL SYSTEMATICS GROUP

VERY few microbiologists would dispute that bacterial taxonomy is in a very confused state. There are many reasons for this. One of the most obvious is that a morphological approach interpreted in terms of evolution, which has been so successful in dealing with the higher plants and animals, is much more difficult, and perhaps impossible, to apply to bacteria. Again, the comparatively small differences in gross morphology, the uncertain significance of serological characters and the difficulty of discovering and measuring physiological properties have all made the taxonomist's task more formidable. Furthermore, and perhaps most important of all, there has been no agreed theory of classification, no overall philosophy which could blend the findings of the biochemist, ecologist, morphologist and immunologist alike into a unified taxonomic scheme. As if this were not enough, there has been added to it a cavalier indifference to the internationally accepted conventions for nomenclature on the part of bacteriologists themselves and an almost complete absence of type cultures, partly due to a failure to use and support the various type-culture collections of the world. For historical reasons the taxonomy of bacteria especially has been carried on as isolated fragments of other disciplines such as medicine or dairying, with the result that the same micro-organism has been known by a different name in each field, and not infrequently their identity has never been realized. Many taxonomic schemes have been devised but have been only cherished by their authors, while others such as Bergey's scheme have been tolerated with much vexation and disappointment for want of something better. Little wonder then that a despairing spirit has pervaded the subject and that Topley and Wilson should comment that "the bacteriologist himself has not in general troubled overmuch as to the validity of a system which has developed rather as a result of luck than of cunning"[1].

In the past few years, however, there has been a renewed interest in taxonomy associated with new ideas and concepts which have stemmed from two main sources, biosystematics and quantitative taxonomy. Some drastic changes in the underlying philosophy of taxonomy are now being proposed. Some of these centre on the nature and definition of taxonomic groups. It is being realized that bacterial taxonomic groups need not be treated as though

they are necessarily phylogenetic. Other developments are based on the assertion that every feature has equal weight in the creation of valid taxonomic groupings. These developments are coming to be called the 'Adansonian method' after the botanist Michel Adanson (1727–1806), who first proposed this concept. By liberating biologists from the impracticable task of allocating different weights to different features it has been possible to develop the use of multivariate analysis employing electronic computors to give some measure of the elusive property which all biologists recognize under such phrases as 'overall similarity', 'affinity' or 'natural resemblance'.

Microbiologists may perhaps compliment themselves on the eagerness with which they are exploring these developments and indeed devising new taxonomic techniques of their own. The outlook in microbial classification has greatly changed and it was this which led to the invitation of a wide range of workers in microbiology, botany, zoology, statistics, biochemistry and electronic computing to attend an informal meeting to discuss these new points of view. The meeting was held on January 12, 1960, at the National Collection of Type Cultures at Colindale, London.

Dr. P. H. A. Sneath (National Institute for Medical Research, London) introduced the subject of quantitative taxonomy and summarized the present position on Adansonian methods. He emphasized the distinction between identification methods, that is those intended to distinguish existing taxonomic groups, and Adansonian multivariate techniques designed to create the taxonomic groups.

Dr. G. D. Floodgate (Torry Research Station, Aberdeen) discussed the problems of anyone trying to do bacterial taxonomy. He mentioned that the accurate identification of bacteria was no mere academic exercise, but a necessity for anyone involved in such fields as the ecology of the soil or the sea; and that identification is impossible when there are neither satisfactory bacterial taxa nor a coherent theory of taxonomy. Despite advances in theoretical taxonomy, there was still the problem of selection of features for taxonomic use, and of course the perennial problem of standardizing the techniques. He also thought that not enough had been done on the theory of hierarchies, and on whether to split taxa or bring them together.

Mr. J. S. L. Gilmour (Botanic Garden, Cambridge) found the Adansonian approach to be very interesting and of wide application—it has even been applied by anthropologists to myths and legends. He agreed that Adansonian methods yield valuable taxonomies for general purposes, but he cautioned against an 'absolutist' approach on the grounds that one must always make some selection of attributes of living creatures, and this selection is always guided by what one is interested in. The mathematical analyses are thus only summaries of mutually agreed classifications based on attributes selected for a particular purpose, and should not be thought of as expressing, in any sense, 'ultimate realities'.

Dr. S. T. Cowan (National Collection of Type Cultures, Colindale) discussed the problem of rank, and pointed out that this is commonly a matter of opinion even when agreement has been reached on taxonomic relations. In addition, the isolation between the different practical sides of microbiology —medical, industrial, agricultural and so on—has badly hampered a unified taxonomy. Dr. G. C. Ainsworth (Commonwealth Mycological Institute, Kew) suggested that agreement might eventually be reached on mathematical values for differentiating between species. Dr. A. J. Cain (Department of Zoology, Oxford) made a plea for a simple nomenclature with few rules, and mentioned the advantages of uninomial names. Dr. C. H. Andrewes (National Institute for Medical Research, London) pointed out that some virologists were now considering the possibility of doing this for the viruses.

Dr. R. R. Sokal (University of Kansas and University College, London) then defended the practice of equal weighting of features for the creation of taxonomic groupings, pointing out that it is well-nigh impossible to justify differential importance of features on any rational grounds, whether genetic, adaptive or phyletic. Attempts to do so were vitiated by unsuspected logical fallacies which have only recently been challenged. He also pointed out that Adansonian methods led to a very stable taxonomy.

Dr. M. Ingram (Low Temperature Research Station, Cambridge) was doubtful whether the equal weighting of features would lead to a better classification than that where the features are weighted.

Dr. N. J. Berridge (National Institute for Research in Dairying, Reading) and Dr. C. S. Cummins (London Hospital Medical College) described recent techniques using paper chromatography which enabled the composition of bacterial extracts and of cell walls to be applied to taxonomy. The use of infra-red spectroscopy was also mentioned. Dr. Cain pointed out that such methods give a flood of new characters which must be co-ordinated with previous taxonomic knowledge. He instanced the comparative serology of birds. Dr. Ainsworth mentioned that recent nutritional and physiological studies had confirmed the taxonomic results obtained by the traditional morphological approach to certain groups of fungi.

In addition to the above there was some very lively discussion in which almost everyone present took part, and which ranged over a very wide field including methods of mathematical analysis, sampling methods, nomenclature, genetics and serology.

As a result of this discussion it was agreed that it would be very useful to form a Group of those interested in microbial systematics within the Society of General Microbiology. Accordingly, with the approval of the Committee of the Society, the Group was constituted at a meeting held in London on April 12, 1960. Drs. Cowan, Sneath and Shewan were asked to act as a small committee to organize the activities of the Group, and Dr. Sneath agreed to be the secretary. The purpose of the group is to promote the advancement of microbial systematics by providing a common meeting ground for those interested in the field. It is envisaged that the Group will hold discussions, arrange for the interchange of information and ideas between microbial taxonomists and taxonomists in other fields of biology and, in general, to assist its members to make the best contribution to this field that they may. Membership of the group is open to all members of the Society of General Microbiology. Visitors will, of course, always be welcome at any meetings the Group may hold. Anyone wishing to be kept in touch with the Group's activities, or desiring further information, is invited to contact Dr. P. H. A. Sneath, National Institute for Medical Research, The Ridgeway, Mill Hill, London, N.W.7.

[1] Topley and Wilson, "Principles of Bacteriology and Immunity", fourth ed., **1**, p. 370 (Edward Arnold, Ltd., London).

RADIOACTIVITY OF SOILS, PLANTS AND BONES

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IN an earlier article[1] observations were recorded of the α-ray activities of various naturally occurring materials such as ashes of plants, etc.; the present contribution gives further observations and discussions, particularly the evidence of high natural radioactivities which might be expected to produce radiation hazards.

In the first place, it has now been possible to identify the radionuclide responsible for the very high recorded activity of the ash of grass from a slow-growing mountain pasture at about 1,500 ft. and under high rainfall conditions at such places as Cymstwyth in Wales, Borrowdale and Rookhope. The former has since grown many-fold in activity to 250 μμc./gm. ash, according to a curve reasonably similar to the growth of polonium-210, from radiolead, and indeed the radionuclide in the same sample has been identified as almost wholly polonium from pulse analyses carried out by U. Facchini in Milan and by Mayneord and Hill[2].

Considering the total activity of the soil on which this grass is grown, 8 μμc./gm., this is a remarkable plant concentration, and it might therefore be expected that ordinary lead would also be concentrated by the plant from the soil. Tests kindly carried out by N. Wells, of the N.Z. Soil Bureau, confirmed this expectation. He found the lead in the soil was 75 p.p.m. on oven-dry weight or 150 p.p.m. on an ash basis. In the grass ash, the lead was 700 p.p.m. and in the 'mat' 90 p.p.m. on oven-dry weight or 1,300 p.p.m. on an ash basis. The soil had a *p*H of 3·1, exchangeable calcium 2·7, and under these acid peaty conditions the uptake of lead is perhaps understandable. Tests of a similarly produced grass collected by Dr. Scott Russell at Rookhope, Durham, on a soil of *p*H 3·3, exchangeable calcium 3·34 and total activity of soil 9 μμc./gm. showed an α-ray activity of 54 μμc./gm. grass ash with a lead content of 500 p.p.m. By comparison the normal activity of lowland pastures of the United Kingdom (with the higher soil *p*H) is of the order of 1–4 μμc./gm. ash with some 25 per cent contribution from the thorium family. Nevertheless, two samples from Reading and one from Princetown collected and ashed 20 months ago have increased in α-activity by 60 per cent, presumably by growth of polonium and possibly radio-thorium. More care in ashing will be necessary in future. (Since the foregoing was written I have arrived at the Institute of Cancer Research, Royal Cancer Hospital London, for further work and have had an opportunity to see a paper by W. H. Burton and N. G. Stewart (*Nature*, **186**, 584; 1960), also to discuss the question with Prof. W. V. Mayneord and to see an unpublished paper by C. R. Hill. [See pp. 208 and 211 of this issue.—Editors.] It is obvious that even on lowland areas measurements on ashes of grasses are influenced considerably by foliar absorption from a fallout of radium-D and -F and the influence of rainfall thereon. All my records will be re-assessed accordingly.)

The uptake of radium by plants from soils through roots may not follow the same principles as the uptake of lead. The dilution is such that the radium may not be an assemblage of cations. As in the case of strontium-90, the calcium ratio is of interest. Two experiments by the N.Z. Grasslands Institute may be quoted. In the first, 'Brown Top' was grown on the same soil, *p*H unlimed 5·4, limed 5·6. The α-activity per gram of ash was 1·7 μμc./gm. unlimed, 1·22 limed, a significant decrease. In another experiment on a severely leached acid podzol at Kaikohe, activity 5·4 μμc./gm. 15 cwt. superphosphate per acre was added generally nearly two years ago, accompanied by (1) 20 cwt. lime (66 per cent $CaCO_3$); (2) 60 cwt. lime; (3) a lime pile. In case (1), the *p*H at 0–3 in. became 5·2 and cation exchange capacity 7·2, and ryegrass grown on it gave 2·8 μμc./gm. ash and White clover 3·1. In case (2), the *p*H became 6·1 and cation exchange capacity 9·5, while ryegrass gave 2·8 and White clover 3·2. In case (3), the *p*H was 7·4, ryegrass 3·3 and clover 3·9 μμc./gm., with 9 and 18 per cent contribution by thorium, respectively. The average lime (CaO) content of the ryegrass ash was 6·75 per cent and of the clover 15·25 per cent, so that expressed as per gram calcium the ryegrass gave twice the pick-up of clover, although on dry-matter basis clover gave roughly 10 per cent more than ryegrass (ash/dry-matter = 0·1). This latter may be contributed to by a correspondingly increased portion from thorium products, 18 per cent as against 9 per cent, although long statistical counting would be necessary to test this point sufficiently. One needs, perhaps, experiments with basic slag instead of superphosphate to avoid definitely the radium carried with the latter. A sample of the lime used gave an α-activity of 3·5 μμc./gm. with some 60 per cent contribution from thorium products.

In another series of field tests in the United Kingdom on five different soil types, the ashes of ryegrass and lucerne gave, in each case, approximately the same α-ray activity. I do not have calcium/ash determinations.

Measurements were also made of wheats grown in the United Kingdom, New Zealand and Victoria (Australia). Total variations of nearly 20 : 1 were observed in the α-activity per gram ash, the activity being mainly controlled by *p*H and calcium exchange availability status, with genetic variety as a significant, but quantitatively less important factor. It is worthy of note in passing that the average soils growing wheat and pasture in the United Kingdom appear to have a markedly higher *p*H and corresponding lime status than the soils of New Zealand. This is possibly the influence of extensive greywacke wheat-growing soils in the latter with *p*H about 5·5, but it results in a very different degree of proportional uptake of radium and presumably of strontium-90 from soil. This factor may also have a bearing on the high results (*Nature*, September 12, 1959) of strontium-90 pick-up reported in the case of the acid soils at Tatyoon, Victoria. Similarly, such considerations in relation to foodstuffs and water may need to be taken into account in interpretating the interesting observations on inhabitants living on the acid granite soils

Table 1

	Material	Ash (per cent of wet weight)	Activity of ash ($\mu\mu$c./gm.)
Niue	Taro (4)	0·8	50–360 CaO 6·1 per cent
Niue	Cassava (2)	1·05	19 CaO 4·0 per cent
Niue	Yam (2)	0·6	5·3
Niue	Kumera (4)	0·7	1·7 to 12
Niue	Banana (1)	—	*c.* 1·2
Fiji	Taro (1)	1·0	0·6 (some thorium)
Raratonga	Taro (1)	1·0	0·6
New Zealand	Potatoes (1)	0·7	0·6
United Kingdom	Wheat	1·8	*c.* 0·9
New Zealand	Wheat	1·43	*c.* 2·3

In the above the first four figures refer to roots. The leaves of taro showed little activity. Kumeras from some parts of Niue showed little activity.

of New York State[3]. It is intended to deal with the various results on wheat and cereals in conjunction with E. D. Greer, of the British Flour Millers Research Association, with whom I collaborated in this section of the work.

In the previous paper, reference was made to the high activity of the soils of Niue Island (long. 19° S., lat. 170° W.), and although the advent of a destructive hurricane has delayed an extended personal visit for observations, yet the readily given help of the administrative officials concerned and particularly of the agricultural officer, F. W. Van Westendorp, has enabled many useful samples to be collected and interesting data to be assembled. Moreover, by courtesy of the Royal Navy (New Zealand), Lieut. A. Mitchell, during a brief visit of H.M.N.Z.S. *Royalist*, made a survey of external γ-radiation and recorded values up to 0·13 mr./hr. over a large area of soil, or some twelve times normal elsewhere. This measurement was taken in the open air. The soil content of radium would correspond to several times this value, as the radon, etc., is given off very readily under natural conditions at Niue.

A variety of ashes of plants grown on the agricultural area of Niue gave the equilibrium activities (1 month) shown in Table 1. Figures in brackets refer to number of samples tested.

In all Niue cases the plant activity is due mainly to radium, though further work is called for, as after nine months the above values were increased 30 per cent in the case of taro, kumera and cassava and more in the case of yam. It may be due to radium-D or other nuclide which produces an α-ray product. Unfortunately, measurements of soil *p*H, etc., were not readily possible, though a general survey of the soils is, I understand, in course of publication by the N.Z. Soil Bureau, and values are of the order 7. Small pieces of coral are disseminated through many of the soils, and it is probable that *p*H was not uniform.

The main foodstuff consumed (80 per cent) by the Niueans is taro, which is seen to be very radioactive indeed, particularly if related to calcium; and since the soil is porous and the drinking water supply is roof-collected rain water, the taro was formerly, except for limited supplies of flying fish, the main source of calcium for bone-growth and maintenance. During the past thirty years, however, increasing supplies of skim milk powder have been consumed, containing calcium of negligible activity. Reconstituted milk is now given to all school children.

Activity of Soil and Origin

As to the parent soil, although only one chemical analysis for uranium has been carried out, giving 59 p.p.m., estimations were made by observing the growth of activity after dissolving with acid and igniting so as to compare the growth of radon and products with similarly treated uranium minerals. Measurements by γ-rays on one soil sample so treated gave 30-fold increase when the radium had attained equilibrium, indicating little uranium-X. In the case of α-rays, typical rough figures for the ratio of activity after a month to initial value were: standard uranium mineral, 1·85; island phosphates, 1·95; Niue soil, 3–4; Niue taro ash, 4; bones of Niue 'bush' hen, 5.

In interpreting these figures, there is uncertainty in the amount of polonium present or driven off by heat—since most of the soils readily give off emanation. Moreover, with the thick-layer counting method used, the greater ranges of radon, radium, radium-A and -C, in comparison with uranium, ionium and radium needs to be taken into account. For example, if the activity is wholly due to ionium + radium in equilibrium with one-third equilibrium polonium, the ratio should be approximately 3. Uranium analyses and radon determinations are needed or a pulse analyser which will resolve uranium-II, ionium and radium. It is obvious, however, from the above that the radium in the soil is several times greater than that supported by the uranium present. It may possibly be that the radium is in excess even compared with its ionium parent. It was at first suspected that the uranium-235/uranium-238 ratio might be higher than the usual 1 : 139. This was negatived later by tests in the United Kingdom with a mass spectrograph on one sample; but in the meantime tests for the daughter products of uranium-235, that is, actinium, had proved interesting. The output from the scintillation photomultiplier was divided and the two channels counted in the manner used by Turner, Radley and Mayneord (*loc. cit.*), but with an interval of about 0·005 sec. in the subsidiary channel instead of 0·32 sec. as used for the determination of doubles due to thoron and thorium-A. The idea was to obtain a measure of actinium-A (half-life 0·002 sec.) and thus of the actinium family.

The results are shown in Fig. 1. No attempt is made at this stage to denote statistical limits of accuracy. Enough doubles were measured in each case to justify the general placing of the points on the graph. Before using the method quantitatively, some study of material distribution, particle size, and spaces in the capsule are called for. At the rates used, the number of spurious apparent doubles should be approximately related linearly to count-rate[4], as indeed is shown by the figures for the various plutonium and other sources not carrying actinium. Incidentally, the plutonium was obtained from ashed bones of small experimental animals—into which plutonium had been injected. As expected, uranium mineral shows residual doubles due to its content of actinium; Travancore sand a lesser number. The soil samples from Niue, etc., do not appear at first sight very abnormal, but it must be appreciated that the content of uranium is far from sufficient to support the other nuclides which contribute to the rate observed, so that the Niue soils must carry excess actinium. However, probably an equally interesting result is that obtained with fossil phosphates such as Nauru, which although as noted above are reasonably in equilibrium as regards uranium-238–radium, etc., indicate an excess of actinium. In Fig. 1, the positions of the points are approximate, but taken together the evidence seems definite and

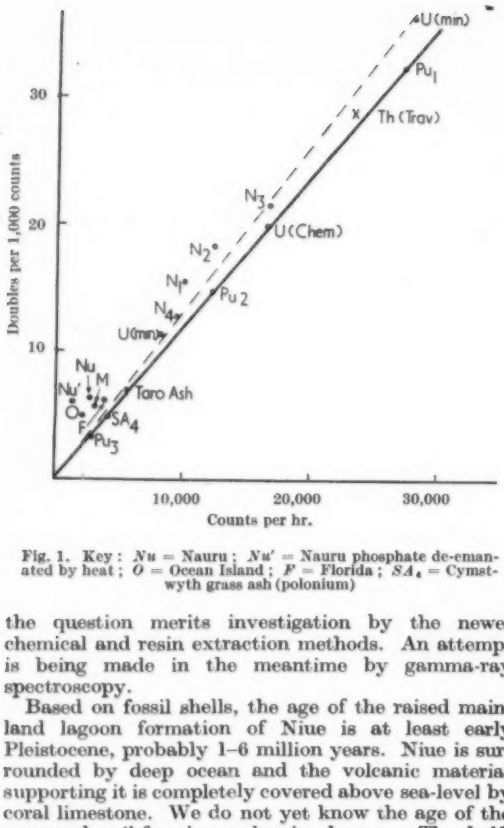

Fig. 1. Key: *Nu* = Nauru; *Nu'* = Nauru phosphate de-emanated by heat; *O* = Ocean Island; *F* = Florida; SA_4 = Cymstwyth grass ash (polonium)

the question merits investigation by the newer chemical and resin extraction methods. An attempt is being made in the meantime by gamma-ray spectroscopy.

Based on fossil shells, the age of the raised mainland lagoon formation of Niue is at least early Pleistocene, probably 1–6 million years. Niue is surrounded by deep ocean and the volcanic material supporting it is completely covered above sea-level by coral limestone. We do not yet know the age of the supposed soil-forming volcanic shower. The half-time period of protoactinium is only 12,500 years, and that of ionium 80,000 years, and it is desirable to find the source of these radionuclides, as presumably these are more recent than the raised lagoon. It may be that there is a similarity in the origins of the radioactivity of Niue soils and island phosphates, the latter being the more mature. The underlying limestone in each case shows pinnacle formations indicating similar leaching. Niue soils have a phosphate content of the order of 2–4 per cent and with a warm rainfall of some 70 in. the leaching-rate is high. Although the late tertiary Pacific phonolites are highly radioactive (*c.* 25 μμc./gm.), yet the volcanic shower may not itself be the source of the whole of the radioactivity but rather the source, after excessive weathering and reaction with lime and sea, etc., of some material such as crandallite which can scavenge and retain certain radionuclides from sea spray or foam. We may possibly imagine such sea spray to be enriched by surface diatoms and fragmental phyto- and zoo-plankton carried ashore as envisaged by A. T. Wilson[5] and which may have extracted radioactivity from sea water.

In a voyage across the Pacific last year in S.S. *Tasmania Star*, samples of sea water were collected daily from a few feet below the surface and immediately boiled to dryness in a stainless steel pan and α-ray measurements made on the dried salt. The results were surprisingly high (0·15 μμc./gm.), and probably due to upwelling from place to place the doubles observed would correspond to a contribution of the thorium family, variable but of the order of 50 per cent. The results were checked on material collected later, during a Pacific voyage by H.M.N.Z.S. *Royalist*, and also on samples at different depths collected by the N.Z. Oceanographic Institute. Moreover, tests were made of the activities of some of A. T. Wilson's foam samples and of mussels and certain sea organisms, and in some cases enhanced activities were found. The results are not sufficient, nor was the material well enough classified; but they do show that the above suggestions merit the making of tests of sea-surface organic matter at Niue, etc., and the gathering of more experimental information on the geochronological aspects of ionium and actinium. Tests of limestone from shell moulds and from pits showed much radium leached from above. This distribution is being investigated.

Activity of Bones and Radiation Hazard

It is natural to extend the observations to the activities of human bones and body organs, but so far opportunities have not presented themselves. Thanks to the Niue Island Dental Service, however, a good supply of teeth has been made available for comparison with teeth from other localities. The average activity of Niue teeth per gram ash was some ten times that of teeth of Londoners, as was confirmed also by measurements at the Institute of Cancer Research by Miss M. Duggan. The average of twenty Niuean teeth was 1·8 μμc./gm. Samples from Hastings (New Zealand), where the soil and water are well supplied with lime, gave a value 0·32, Raratonga 0·2, Lower Hutt (where low-activity calcined lime is added to the artesian water to bring the *p*H to 85) 0·4, Auckland, Wellington and Sydney, N.S.W., *c.* 0·7. In all cases the activity is mainly due to radium—in Niue, almost wholly so. The relative contribution by food supplies and water supplies to teeth and skeletal radium is not yet known. Independently of lime fortification, the flour in the United Kingdom contains considerably less radium per gm. ash than in New Zealand or Australia. However, the above results are to be taken as approximate—they relate to a few samples only; there is possibly an age relationship. Thus the teeth of ten adults of age seventy, kindly supplied by the superintendent of the United Dental Hospital, Sydney, gave a preliminary average of 0·4 μμc./gm., whereas unerupted teeth of children aged twelve gave a value of 1·0 and erupted children's teeth of about the same age 0·5. Breakfast foods from Australia were examined, and no case of added radioactive material was found, as was the case in two brands from the United Kingdom. The relative low activity of teeth of elderly people may have a similar explanation to that given in my earlier article and relating to sheep of forty years ago, or some deposited nuclide which decays with time.

Teeth extracted from skeletons found in limestone caves of Niue, but of unknown age, gave the same value as present inhabitants, indicating presumably that the radioactivity has been a feature of Niue for at least a few hundred years. It is reported that fine grains of charcoal have been found in underground caves into which surface water readily drains. If so, and if these are connected with the effects of an ash shower, it should be possible to obtain a date by carbon-14 methods.

Probably the most interesting results obtained were those of the bones of hens. The bones of non-

descript breed, so-called 'bush' hens, fed on the country, plus a certain amount of local dried coconut, gave 60 μμc./gm. bone ash. This, in humans, would be greater than accepted tolerance. The bones of recently imported Rhode Island hens at the prison farm and fed on wheaten mash imported from New Zealand, gave a value of 24, while a single sample of the contents of two eggs from the latter gave a value of 4·4. If this latter result is confirmed, it will correspond with the discrimination or reduction in activity of the fœtal offspring in the case of the cow and ewe, as recorded in my previous article. It appears that the same discrimination may not occur in the case of humans, though it is said to occur in the strontium-90/calcium ratio, but the activity of normal human bones is in any event only about a tenth of those of cows, sheep and rabbits.

The Niueans appear to be healthy and vigorous, though somewhat sparer than the other Polynesian groups, to which they are racially related. Probably they have to work harder. With such a small population, namely 4,500, great care is necessary in treatment of statistics of cancerous conditions or of congenital malformations or impairments which might be associated with the large background γ-radiation and food α-activity. Similarly, regarding the occurrence of plant mutations—these are indeed observed in bananas and other plants, but there is as yet no comparative data from other Pacific islands showing less natural activity.

One might expect the possibility of an abnormal sex ratio, and this question is being looked into by the School of Demography, Canberra, which has made a close study of Pacific Island populations. As to fertility, the following figures deduced from a report kindly made available by Drs. McCarthy and Marples, of Otago, may be significant. These authors visited a village in Niue in 1955 for the purpose of investigating certain blood conditions and incidentally noticed the predominance of childless marriages and were led to a close investigation of a group of 100 cases. At that time the high radioactivity of Niue was not known. The figures are: childless marriages, 19 per cent; stillbirths, 6·1 per cent; infant deaths, 9·8 per cent; deaths 1–3 yr., 6·35 per cent. Figures for marriages about 1925 were higher than the more recent; in fact, the infant mortality is now much lower, but an improvement had occurred before the advent of antibiotics for treatment of venereal disease, etc. It is possible that the distribution of skim milk from the hospital, which started nearly thirty years ago, has in some cases had the effect by replacing the calcium from taro with its high radium/calcium ratio by calcium of milk with negligible radium content. Similar evidence might be deduced from the history of a certain hamlet of Fatiau, of 85 persons, established some eighty years ago, the inhabitants of which, knowing nothing of radioactivity, yet were constrained to move as a whole ten years ago to a more wind-exposed site, Vaiea, 2 miles away, because of unknown but feared causes of infertility and infant mortality. However, I am well aware of some of the pitfalls of such statistics; epidemics of influenza or measles can in these islands make great differences in the figures in particular quinquennia; and similarly fashions in diagnosis, etc., change. But if the causes of low fertility are contributed to by high local radioactivity, may it not be that in the Darwinian sense selective breeding of resistant types has taken place? It would appear that Niue has been populated for fully a thousand years. There is ample evidence that different strains of small animals differ markedly in resistance to radiation.

It is hoped to plan carefully and carry out an investigation of these problems during the coming year, and suggestions and help are invited to this end. If the results of Gentry and Bulin (*loc. cit.*) are due to other than selective population migration, then these questions are very important indeed.

In conclusion, I would like to thank all those who have kindly assisted so freely, in particular, W. H. Ward, director of the laboratories at the Dominion Physical Laboratory, for providing laboratory space, etc.; A. H. Allen and Mr. Penton, of the Electronics Division, for improvements to the apparatus; Dr. J. K. Dixon, of the Soil Bureau, for useful soil discussions; and the staff of the Coal Survey Laboratory and Dominion Laboratory Division for ashing facilities and analyses; the secretary of the N.Z. Island Territories Department and the Niuean Administrator for advice on Niue matters; the agricultural officer, F. W. van Westendorp, for provision of samples; and lastly, the manager and officers of the Blue Star Line for facilities to make measurements on board ship during three voyages. The ships proved to have low contamination and background activity, and enabled reliable measurements to be made more easily than on land.

[1] *Nature*, **183**, 924 (1959).
[2] *Nature*, **184**, 667 (1959).
[3] Gentry, J. T., and Bulin, G. V., *Amer. J. Pub. Health*, **49**, No. 4, (April 1959).
[4] Marsden and Barrett, *Proc. Phys. Soc.*, **23**, 367 (1911).
[5] *Nature*, **184**, 99 (1959).

OBITUARIES

Sir Robert McCarrison, C.I.E.

Major-General Sir Robert McCarrison, who died in Oxford on May 18 at the age of eighty-two, was a pioneer of nutritional research whose scientific reputation was even greater abroad than in Great Britain. Particularly is he remembered in India, where he spent much of his life.

After graduating M.B. at Belfast in 1900, McCarrison immediately entered the Indian Medical Service. At his first station he encountered and investigated what he correctly believed to be a fever transmitted by the sand-fly (*Phlebotomus*), and then he began a classical investigation of goitre and cretinism in the foothills of the Himalayas. He noticed the connexion between polluted water and endemic goitre, and he produced this condition in himself and volunteers by drinking the suspended matter of grossly polluted water.

He then turned to study beriberi in particular, and nutritional disorders in general. Little work on these lines had been done in India, though McCarrison was particularly impressed by the work of McCay (1912) on the importance of dietary protein. His approach was original and successful; he realized that single dietary deficiencies were unlikely to occur in man, and that ill-health might well be produced by combined deficiencies. So he fed lower animals such as rats on the type of poor diets being used by various tribes, and produced in the animals diseases similar to those frequently occurring in such tribes. This type of approach was very different from that of Hopkins, McCollum, Evans and others, who were feeding lower animals on purified diets. Both approaches were needed, and it is surprising that short-sighted scientists levelled criticism at McCarrison's method, which he summed up in these words: "My own method, on the other hand, has been to observe the more general symptomatic and pathological effects of faulty food on the animal body as a whole, and thereby to ascertain what forms of human illness might reasonably be attributed to it". This approach led to a series of papers on the pathogenesis of deficiency disease.

He met criticism not only from scientific colleagues but also from the Finance Department. His work was frequently stopped, and much he paid for himself. In 1926 Lord Linlithgow visited India as chairman of the Royal Commission on Agriculture, and insisted on going to see McCarrison's work. The Commission recognized the importance and promise of what he was doing in Coonoor; and in 1929 his unit was made into the Nutrition Research Laboratories, now moved to Hyderabad.

In 1935, McCarrison retired and settled in Oxford. He and Lady McCarrison, who survives him, kept open house, and they had constant visitors, especially in the form of the local children and distinguished scientists from abroad. During the Second World War, McCarrison was chairman of various committees, and during 1945–55 he was the first director of postgraduate medical education in the University. His academic honours were many, and he was knighted in 1933.

His more important papers were edited by me and presented to him as a *Festschrift* on his seventy-fifth birthday. Nothing pleased him more than a telegram from the Minister of Health of India, Rajkumari Amrit Kaur, expressing the gratitude of that country for his great services to the science of human nutrition and the advancement of the public health.

H. M. Sinclair

Dr. R. K. Schofield

Robert Kenworthy Schofield, reader in soil science in the University of Oxford, died on June 8, at the age of fifty-nine.

He entered Trinity College, Cambridge, in 1919, obtained a first in Part II of the Natural Sciences Tripos, and the hobby of country dancing. In a testimonial, J. J. Thomson ". . . was impressed by the promise he showed, he had ideas and the energy and skill to test them by experiment". Already interested in surface physics, Schofield sought research experience in the Colloid Science Laboratory, and his first two papers (with E. K. Rideal) were on the kinetic theory of surface films. After two years at Durham (1926–28) as lecturer in physics, he joined B. A. Keen at Rothamsted Experimental Station with an introductory description from I. O. Masson that fitted Schofield throughout his life: "As a physicist he is all round. He is a very nice fellow indeed, full of go and good spirits, and we all like him."

Schofield spent twenty-seven years at Rothamsted, succeeding Keen as head of the Physics Department in 1949, and then took charge of the much bigger Chemistry Department on the death of E. M. Crowther in 1954. Two years later he moved to the Department of Agriculture, Oxford, so returning to the academic atmosphere for which he always had a great affection.

Though his early Rothamsted work was mainly on the rheology of clays and similar materials, done in collaboration with G. W. Scott Blair, by 1935 he had also published papers on proteins, on the diffuse double layer—and on soil water. One of these was "Schofield (1935)", perhaps the most quoted reference in the literature of soil science. Others have expanded his thermodynamical treatment—a few think they have improved it—but "The *p*F of the water in soil" still remains the basis of any worth-while discussion of soil–water equilibrium. Leaving problems of bulk movement to those interested in drainage and evaporation, Schofield concentrated on the behaviour of water as an electrolyte in contact with the charged faces and edges of clay particles. His ideas on the ionic forces in water films were used in physical studies of soil structure, soil permeability and soil rheology; and in chemical problems of soil acidity, cation exchange, and the availability of nutrients.

There will be widespread regret that he did not write a synoptic survey of this work and of his ideas for its future development, but even without it Schofield leaves behind him an enviable world reputation in soil science and related technologies. Part of this was attained through his publications (more than eighty as sole or joint author), and part through an extremely wide range of personal contacts. There seemed to be no limit to his fund of ideas, and they were passed on liberally to anyone willing to listen. As a consequence, he was much in demand, nationally and internationally, for committee work and for discussion meetings. Selecting only a few events and activities in his career, Schofield was chairman of the Colour Group of the Physical Society; for six months, 1951–52, he was visiting professor at Cornell University; at the time of his death he was president of the British Society of Soil Science, and chairman of Commission I of the International Society; and, specially pleasing to him, he had an honorary doctorate conferred on him in Lisbon in 1956.

Throughout a very busy life, his main interest outside science was in country dancing, and he was an enthusiastic performer and administrator in the English Folk Dance and Song Society; at the time of his death he was 'Master Squire of the Oxford Morris Men'.

In his combination of qualities as man and as scholar, Schofield was unique and irreplaceable. He leaves behind a host of grateful friends, at Rothamsted, in Oxford, and elsewhere, all proud of their association with him.

H. L. Penman

NEWS and VIEWS

Mathematical Physics at Birmingham : Prof. S. Mandelstam

Dr. Stanley Mandelstam, who has been appointed to a new chair of mathematical physics in the Department of Mathematical Physics of the University of Birmingham, comes from South Africa, where he graduated in engineering and in science (physics and mathematics) in the University of the Witwatersrand. As a student he was a co-author, with W. Yourgrau, of a book on the "Variational Principles in Dynamics and Quantum Theory". It was published by Pitman in 1955. He took Part 2 of the Natural Sciences Tripos and Part 3 of the Mathematics Tripos in Cambridge, and his Ph.D. in mathematical physics in Birmingham in 1956, and he has since carried out research in Birmingham, Columbia and Berkeley. His first original papers were concerned with quantum field theory and with the phenomenological description of pion production in nucleon–nucleon collisions. He is best known, however, for a new method in quantum field theory, now known as the Mandelstam representation, in which the general analytical approach of dispersion relations is generalized to the treatment of a scattering or reaction amplitude as a function both of the energy and the momentum transfer. This method has had a profound influence on the work of many authors in the past few years, and Dr. Mandelstam has published himself a number of investigations, some in collaboration with G. F. Chew, and others in which an attempt is made to derive from this a complete solution of the problem of the mutual scattering of π mesons, which from this point of view would seem to be the simplest problem in high-energy physics.

Applied Mathematics at Bangor : Prof. D. R. Davies

Dr. David Rowland Davies has been appointed to the newly created chair of applied mathematics in the University College of North Wales, Bangor. Dr. Davies graduated in mathematics at the Imperial College of Science and Technology (University of London), where he afterwards studied for the degrees of M.Sc. and Ph.D. More recently, in 1958, he was awarded the degree of D.Sc. by the University of London. After a brief period as a meteorological officer in the Royal Air Force, Davies turned to university teaching as a career in 1946 and held posts at Liverpool, Southampton and Aberystwyth before taking a lectureship at Sheffield in 1949. He was there promoted to a senior lectureship in 1956 and appointed reader in applied mathematics in 1959. Davies has maintained his early interest in meteorology and is a Fellow of the Royal Meteorological Society and of the Royal Astronomical Society. His research interests have concentrated on atmospheric diffusion, evaporation from limited, saturated areas, and on heat-transfer in laminar and turbulent boundary layers, and he is the author of numerous papers on these topics. In Sheffield he has generated interest in this research, and his research students know him as a stimulating and enthusiastic, if demanding, leader ; at the same time, he is recognized as an inspiring teacher at the undergraduate level. As a Welshman by birth, it is not inappropriate that Davies should return to the Principality as the first holder of a new chair.

Zoology at the University of Leeds : Prof. E. A. Spaul

Prof. E. A. Spaul, whose retirement from the chair of zoology in the University of Leeds takes place this summer, has been well known both in the North of England and in London for his active and valuable membership of many committees and examining bodies. He left school at the beginning of the First World War, was commissioned, and remained on active service until 1918. He took part in many of the historic battles, and towards the end of the War he was transferred to gas warfare. After the War, he set himself the double task of graduating in zoology and at the same being a member of the teaching staff of the Zoology Department of Birkbeck College under Prof. Gordon Jackson. This was a time when interest in hormones was acute, and he ultimately gained his Ph.D. and D.Sc. for a study of pituitary action in amphibians. He was one of the first zoologists to move into the now active field of comparative endocrinology. He remained a member of the staff of the Zoology Department of Birkbeck College, rising to the position of reader, until 1933, when he was appointed to the chair of zoology in Leeds. While still retaining his interest in endocrinology, he then turned his attention mainly to teaching, to administration and to the encouragement of research by the younger people in his Department. In addition, he always encouraged sport, particularly rugby and hockey, among the students. He himself in his younger days was a brilliant rugby player, and recently he has for many years been chairman of the Committee in charge of the Leeds University Sports Grounds. Both he and his wife, who has also been most active on a variety of committees, will be greatly missed in Leeds.

Dr. J. M. Dodd

Dr. J. M. Dodd, who will succeed Prof. E. A. Spaul at Leeds, was educated at the White House School, Brampton, in Cumberland, and at the University of Liverpool. After graduating in zoology in 1938, Dodd taught for a short time at Cardigan Grammar School, and thereafter was on active service in the R.A.F. during the War. At demobilization, Dodd went as assistant lecturer to the Zoology Department of the University of Aberdeen, and here he came in contact with the Hogben school of comparative endocrinologists ; Dodd's own work in this field stems from this time. A year later, in 1947, the late Sir D'Arcy Thompson appointed Dodd as lecturer to the Zoology Department of the University of St. Andrews, his particular charge being to resuscitate the Gatty Marine Laboratory, which had been asleep for the previous thirty years. From 1947 to the present date, Dodd has worked in St. Andrews, being appointed reader in zoology in 1957 and director of the 'Gatty' in 1959.

Dr. Dodd will go to Leeds leaving an impressive record of achievement behind him in St. Andrews. The Gatty Marine Laboratory has been well and truly resuscitated in these past thirteen years, during which time two major extensions have been built and a research tradition re-established. Dr. Dodd's main stream of research concerns the pituitary–thyroid–gonad interrelations of cold-blooded vertebrates. He has published widely in this field and, supported financially by the Nuffield Foundation and by the University, and scientifically by his wife, Dr. M. I. H. Dodd, who is also an endocrinologist, he has trained many research students while his own work has progressed. Dr. Dodd's appointment to the chair at Leeds is a timely and well-deserved recognition of his abilities as scientist and teacher. His colleagues at St. Andrews are well aware of their own loss, both personal and scientific, but their loss is Leeds' gain.

U.S. National Academy of Sciences: Foreign Associates

The following have been elected Foreign Associates of the U.S. National Academy of Sciences: Prof. E. A. Brun, professor of aeronautical engineering in the Ecole Nationale Supérieure de l'Aeronautique; Sir Cyril Hinshelwood, president of the Royal Society and professor of chemistry in the University of Oxford; Dr. L. D. Landau, head of the Theoretical Section, Institute for Physical Problems of the Academy of Sciences of the U.S.S.R., and professor of physics in the University of Moscow; Prof. L. F. Leloir, research professor of biochemistry in the Facultad de Ciencias Exactas y Naturales, University of Buenos Aires.

Science and Technology in Africa South of the Sahara

The Scientific Secretary to the Scientific Council for Africa South of the Sahara, Dr. E. T. Verdier, has pointed out that the reference to the Council in the recent article, "Scientific Research in the Overseas Territories of the British Commonwealth" (*Nature*, May 14, p. 501), does not make it clear that the members of the Council are chosen as representatives of a scientific discipline and that they are not responsible individually to the country from which they are drawn. Its constitution provides that "members of the Council shall be eminent scientists able, so far as possible, between them to speak with authority on all the main branches of the sciences of direct interest to Africa South of the Sahara, regard also being paid to equitable representation of the geographical sub-divisions of Africa and of the countries and territories concerned". Further, "Vacancies on the Council shall be filled by the Council itself, subject to confirmation of its nominations by the participating Governments". The Council is thus a body of independent scientists whose primary allegiance is to the advancement of science for the benefit of Africa, and as such it is well qualified to act as a counsellor to the member Governments of the Commission for Technical Co-operation in Africa South of the Sahara.

This Commission, as distinct from the Council, is an inter-governmental organization which includes to-day, besides the six original members (Belgium, France, Southern Rhodesia (now the Federation of Rhodesia and Nyasaland), Portugal, the Union of South Africa and the United Kingdom), the newly independent States of Ghana, Liberia, Guinea and the Cameroons. The Scientific Council/Commission is financed by the member Governments on a percentage basis, each in its own currency, the United Kingdom and France contributing the biggest percentage (just under 20) of the total cost in 1960 of about £250,000, which is distributed over some fifteen separate budgets. Dr. Verdier testifies that whatever else the Scientific Council has accomplished in the ten years of its existence, in spite of rapid changes in Africa, it still provides a common meeting place where representatives of its member Governments, whether scientists or not, can discuss technical matters of importance to the continent of Africa without being hampered by other considerations which often make international co-operation so difficult.

The International Council of Scientific Unions

The Year Book of the International Council of Scientific Unions for 1960, besides a Calendar of Arrangements for 1960, lists the staff of the Secretariat, members of the Bureau and the Executive Board, as well as the National and Scientific Members of the Council and the countries adhering to the Unions (Pp. 109. The Hague: International Council of Scientific Unions, 1960). Details are also given of the membership of the special committees, joint commission, and executive bodies of the permanent services of the International Council. With the statutes and by-laws of the Council, the rules and charters for the special committees and permanent services, the particulars of the commissions of the Unions, of the relations of the Council with the specialized agencies of the United Nations, the list of addresses of international organizations, and the alphabetical list of members of the joint commission and other organizations of the Council and of the officers of the Scientific Unions, the Year Book is a most useful reference work for scientists and others engaged in international scientific activities. The Treasurer's report and financial statement issued as a separate paper show an excess of income over expenditure for the year ended December 31, 1959, of 17,568 dollars (Pp. 12. The Hague: International Council of Scientific Unions, 1960).

Irrigation in Great Britain

The second report to the Central Advisory Water Committee of the Sub-committee on Growing Demand for Water must be one of the shortest official reports on record (Pp. 5. London: H.M. Stationery Office, 1960. 6*d*. net). Extending to two pages only, the first deals with the appointment and terms of reference of the sub-committee and explains that the document is an interim report on uncontrolled abstractions of surface water, with special reference to irrigation water for agriculture. The second page proposes the early introduction of a temporary method of control through the river boards in view of the risk that growing abstractions will seriously deplete the natural flow of rivers at the time when they will be at their lowest levels. A detailed report is promised at some future date on the ultimate method of control, and this will doubtless reveal a selection of the data which has led to the early publication of the sub-committee's conclusion. While the sub-committee also recognizes that ultimately "provision should be made for conservation and storage so that water would be available for all legitimate purposes", the urgency of this need is only being realized slowly in Great Britain. So far H.M. Central Advisory Water Committee has only been prepared to look forward

as far as 1965. In contrast, the United States Select Committee on National Water Resources is evaluating water needs for 1980 and beyond to the year 2000 on the basis of low, medium and high-level population increases.

If British national policy is to secure the maximum food output from the agricultural industry, farmers in south-east England should be actively encouraged, rather than discouraged, to irrigate; and although some form of temporary control of abstractions may now be advisable because of lack of foresight in the past, the time has surely arrived when a much more positive approach to the whole question of water conservation and supply in Great Britain is desirable so that the maximum benefit may be derived from the ample precipitation available.

Optics and Spectroscopy

Optics and Spectroscopy is now added to the list of full English translations of Russian scientific journals; it is published in the United States on the initiative of the Optical Society (6, No. 1. Translation of the Russian journal *Optika i Spektroscopiya*. Pp. iv+84. Published monthly. Subscription rate 25 dollars plus 3 dollars for postage. This rate includes the Journal of the Optical Society of America. New York: American Institute of Physics, 1959). This gives a welcome guarantee of the standards to be adopted. Five volumes of the original, in Russian, have already appeared, and the translations of the sixth and subsequent volumes will only be available as a joint subscription with the *Journal of the Optical Society of America*. In both the five previous volumes in Russian and the present translated issue, the coverage of the journal has corresponded quite closely with that of the *Journal of the Optical Society of America*, except for a surprising absence of papers on instrumental optics, diffraction and coherence problems. On the other hand, atomic and molecular spectroscopy, luminescence and optical properties of materials are all fully represented. From many sources it is known that very extensive work in instrumental optics is done in the Soviet Union, and it would be of great benefit to both optics and physics generally if the relevant publications were not only made known but also published in translation. It is not stated whether separate reprints of these translations will be sold. If not, it is to be regretted, for both the content of the papers in the present issue, and the excellence of the translations, will create a demand for them.

Bibliography of Indian Scientific and Technical Publications

In connexion with an exhibition in February 1960 of scientific and technical books published in India, organized by the Council of Scientific and Industrial Research, India, the National Library, Calcutta, has compiled a bibliography of Indian Scientific and Technical Publications (Pp. xii+195. New Delhi: Council of Scientific and Industrial Research, 1960. Rs. 25). The bibliography is based mainly on publications supplied in response to requests addressed to publishers, universities, research institutions, etc., and supplemented from information or material in possession of the National Library. Resources for compilation of a bibliography in the usual way were not available and it is proposed to supplement the present bibliography by such a compilation later. The present material is in two parts, the first containing the entries in the Indian languages, and the second the entries in English. Publications are arranged according to the Dewey Decimal Classification, and there is a consolidated subject index to both parts and separate alphabetical author indexes to each part. Of the English publications, 493 relate to agriculture, 315 to engineering, 119 to mathematics, and 100 to physics.

The South African Museum

The *Annals of the South African Museum*, Vol. 45, Part 3, contains Part 5 of Prof. J. H. Day's detailed work on the polychæte fauna of South Africa. The present contribution deals with errant species dredged off the Cape coasts and is the first account of those organisms which occur below tide-marks. The prime object of this dredging survey is to determine distribution patterns around the southern part of Africa. Both the Hydrographic Section of the South African Navy and the Lamont Geological Observatory have provided facilities for the collection of material, though the bulk was obtained by members of the Department working from small boats during university vacations. The paper is illustrated with text figures.

Preservation of Films of Historical Value

The National Film Archive, created twenty-five years ago to undertake the permanent preservation of selected moving pictures of historical importance, either as works of film-art or as records of the life of our time, has now issued Part II of its published catalogue, "Silent Non-Fiction Films 1895–1934", to which Sir Arthur Elton contributes a foreword (British Film Institute. National Film Archive Catalogue, Part 2. Pp. x+195+12 plates. 15*s*.). The first volume ("Silent News Films, 1895–1933") was published in 1951, and a third, devoted to silent fiction films, is in preparation. The 1,054 entries are arranged chronologically under the country of origin, using wherever possible the date of release and the original release title, and the length and a short synopsis are also given. The great majority—727—of the entries are from Great Britain, and there is also an alphabetical index to film titles and a subject index.

The Archive, which is financed out of the Government grant made annually to the British Film Institute and administered by a committee appointed by the Governors of the Institute, has also issued a booklet describing the work of the Archive (The National Film Archive. Pp. 16. London: British Film Institute, 1960. 2*s*. 6*d*.). This has now built up a collection of 6,000 films, apart from newsreel material, covering the period 1895 to the present day and representing the work of more than thirty countries. Individual *bona fide* students engaged in some approved work or research may view preservation copies on an "Editole" in the Archive's premises under the supervision of the Archive's staff, and, with permission of the owners and under such conditions as they may stipulate, certain films may be shown in the National Film Theatre of the British Film Institute. Where the owners of historically important films are willing to allow them to be used for study by schools, universities, adult education groups and film societies, duplicate copies are made for hire through the British Film Institute's distribution service, and more than 200 films are available for distribution in this way. It is emphasized that the National Film Archive is a national film museum,

being one of the first of nearly forty throughout the world, grouped together in an international federation of archives with its headquarters in Paris, and devoted to the permanent preservation of films of historical value, and it is no part of its function to duplicate the work of the many production libraries existing within the film industry.

"Clean Air Year Book"

A useful feature of the "Clean Air Year Book for 1960" is an outline summary of the Clean Air Act which came into force about two years ago, together with details of relevant Acts and by-laws. The latest estimates of the pollution of Britain's atmosphere show that more than a million tons of smoke are emitted yearly from domestic fires compared with half a million tons from industry and 100,000 tons from the railways. On the other hand, domestic chimneys contribute only 100,000 tons out of the 900,000 tons of grit and dust that are emitted. Sulphur dioxide gas, emitted from all solid fuels and fuel oils, total 5½ million tons, to which domestic fires contribute nearly a million tons. The "Year Book" contains a complete list of local authorities which have smoke-control areas or smokeless zones in operation or approved. So far as acreage is concerned, Hayes and Harlington in Middlesex have more smokeless zones than any other town or city. Another feature of interest is the chronological history of the struggle against air pollution which began in 1273 when the use of coal was prohibited in London as being "prejudicial to health". The "Year Book" can be obtained from the National Society for Clean Air, Palace Chambers, Bridge Street, London, S.W.1, price 2*s*. 4*d*. including postage.

The Scottish Field Studies Association

The annual report for 1959 of the Scottish Field Studies Association, presented to the eleventh annual general meeting at Perth on May 7, at which Mr. P. F. Holmes, warden of the Malham Tarn Field Centre, spoke on the importance of field studies in modern education, records a slight reduction in the number of courses offered, as it was not possible to make arrangements at Kingussie, and the number of student-days fell from 3,642 to 2,972 (Pp. 28. Glasgow: Scottish Field Studies Association, c/o Department of Botany, The University, 1960. 2*s*. 6*d*.). The paid ordinary membership on December 31, 1959, was 534 and the number of affiliated bodies 33. The Bursary Scheme continued successfully and 61 members of local scientific societies attended courses as bursars. Half the eighteen courses arranged were planned for the Association's own field centre at Garth; four were in co-operation with the Holiday Fellowship, Ltd.; two in hotels, and two at Newbattle Abbey. In his address, Mr. Holmes stressed the importance of an understanding of country problems, and of conservation keeping pace with the increase in the numbers of people visiting country districts and the inadequacy of normal class-room techniques for this purpose. New methods must be devised and especially field studies for younger children. The annual report is accompanied by an admirable illustrated paper by Dr. Joy Tivy on "The Geography of the Garth Area: the Central Highlands in Miniature", based on material collected and compiled by members of the various Geographical Studies Field Classes who attended Garth during the summers of 1957–59.

Rock Shelter Paintings near Bauchi in Northern Nigeria

During an investigation in the area around Geji, not far from Bauchi, Hamo Sassoon, deputy director of the Nigerian Department of Antiquities, found several painted rock-shelters. Of these the most important was near Geji itself. Four styles of painting were determined: there is a naturalistic style, the painting being made in solid red pigment; two series in a more diagrammatic style; and another series once again in solid red pigment, but much less naturalistic than the first. Antelopes, cows, monkeys, men and a horse are depicted. This last, which occurs in one of the diagrammatic series, is important as it would seem that the horse would not have been known at Geji before about A.D. 1500. Only two superpositions can be observed and they happen not to be very helpful. It is not, then, possible to determine the relative ages of the four series, and as to an absolute date one can only say that one of the diagrammatic series cannot be earlier than A.D. 1500. Although the drawings are protected from the weather by an overhanging rock, it is very unlikely that any rock-shelter paintings can be of any vast antiquity. Precipitation and subsequent evaporation degrade the walls and any paintings tend to disappear. Only in deep caves, where conditions have not changed for long periods, can one expect survival. But the newly found paintings in Nigeria are of considerable interest. The local inhabitants have no idea who made them, but they do attribute magic qualities to them.

Relaxin

In a paper presented before the American Society of Biological Chemists in Atlantic City, N.J., Edward H. Frieden, of the Arthur G. Rotch Laboratory, Boston, Mass., has reported his analyses of relaxin (United States Department of Health, Education, and Welfare: Public Health Service. Publication No. 739: Highlights of Research Progress in General Medical Sciences, 1959. Pp. v+23. (Washington, D.C.: Government Printing Office, 1960.) 15 cents). Relaxin is secreted by the ovaries and apparently serves to relax the uterus during childbirth. Previous work by Frieden had indicated that relaxin was composed of a single molecular series; he now suggests that there are three components. The relaxin preparations, isolated from the ovaries of pregnant sows, were separated in a solvent system of 2-butanol and 0·2 per cent trichloracetic acid. A total of 355 transfers was made, with the relaxin compounds spread rather uniformly over 50 tubes. Pooled material from this distribution was re-run in the same solvent system, separating the three components. The amino-acid contents of the components were determined by paper chromatography of their acid hydrolysates and were found to be qualitatively identical. They included cystine, aspartic acid, glutamic acid, glycine, serine, histidine, lysine, arginine, alanine, valine, theonine, leucine and *iso*leucine.

U.S. National Centre of Atmospheric Research

Dr. Walter Orr Roberts, of the High Altitude Observatory, Boulder, Colorado, has been appointed director of a (U.S.) National Centre of Atmospheric Research. The National Science Foundation has granted 500,000 dollars to the University Corporation

on Atmospheric Research to assist in establishing the Centre, which will consist of a central scientific group to stimulate and supplement university research. It will also provide facility management for what may become a large and widely dispersed research effort. Research programmes to be undertaken by the group will probably fall into four categories: atmospheric motions, energy exchange processes in the atmosphere, water substance in the atmosphere, and physical phenomena in the atmosphere. It is probable, however, that the staff will require about a year of investigation and exploratory work before deciding upon specific long-term research projects.

Oliver Memorial Fund Award

THE Committee of the Oliver Memorial Fund has announced that it intends making its fourteenth annual award of the value of £50 to a British subject whose original work, or services in connexion with blood transfusion, is considered to be a notable contribution to the research, organization or donor aspect of this subject. Applications and communications directing attention to suitable candidates should be submitted before September 30, and should be sent to the honorary secretary, Mrs. F. E. Bedborough, 105 New Park Avenue, London, N.13.

University News: London

THE title of professor of physics in the University of London has been conferred on Dr. E. H. S. Burhop in respect of his post at University College.

Queen Elizabeth College has received a grant from the Leverhulme Trust Fund of £3,800 over a period of two years to enable a sociological research programme to be started in the Department of Nutrition. The work will be carried out by Dr. Paul Morpurgo, who has been appointed Leverhulme Research Fellow in the Sociology of Nutrition for two years as from October 1.

A Wellcome Research Fellowship has been awarded to Dr. Angela E. R. Taylor to enable her to undertake in the Department of Biology research on the metabolic requirements of helminths, using radioactive tracers.

The London Research Foundation is making a grant to Queen Elizabeth College of £56,000 over a period of seven years to further the research work of the Department of Nutrition, with special reference to its work on fertility control.

Announcements

DR. J. M. WINTERBOTTOM has been appointed director of the Percy Fitzpatrick Institute of African Ornithology as from September 1. The new building, on the campus of the University of Cape Town, which is to house the Institute, is now completed.

THE Roentgen Prize of the Justus Liebig University of Giessen has been awarded to Mr. J. B. Adams, acting director-general of CERN (Geneva) and director of CERN'S proton synchrotron division.

THE Langley Medal of the Smithsonian Institution, Washington, has been awarded posthumously to the rocket pioneer, Dr. Robert H. Goddard, who died in 1945, for the rocket experiments he started half a century ago at Clark University.

THE Warner Memorial Medal of the Textile Institute has been awarded to Prof. C. S. Whewell, professor of textile technology in the University of Leeds. The Warner Medal is awarded in recognition of outstanding work in textile science and technology, the results of which have been published, and particularly for work published in the *Journal of the Textile Institute*.

THE Science Museum Library has recently been presented with a collection of Japanese scientific and technical books and dictionaries on behalf of the Prime Minister of Japan, Mr. Nobusuke Kishi. The Library, as the result of this presentation, now possesses a very complete collection of such recent books in English or with English summaries, in addition to a large number of current Japanese scientific and technical periodicals.

THE Faraday Society is organizing a general discussion on "The Physical Chemistry of Aerosols", which will be held at the University of Bristol during September 13–15. Further information can be obtained from the Assistant Secretary, Faraday Society, 6 Gray's Inn Square, London, W.C.1.

THE eighth International Congress of Blood Transfusion is to be held in Tokyo during September 12–15. Further information can be obtained from Tomio Ogata, Blood Transfusion Research Laboratory, Japanese Red Cross Society, Shibuya, Tokyo.

LA Società Italiana di Fisica is organizing an International Summer Course on "Solid State Physics" at the 'Centro Studi Nucleari di Ispra' during September 5–24. Further information can be obtained from Prof. G. Poloani, Società Italiana di Fisica, Via Saldini, 50, Milano.

THE tenth International Congress of Applied Mechanics will be held in the Congress Building at Stressa during August 31–September 7. Further information can be obtained from the Secretary of the International Committee, Prof. Mekelweg 2, Delft.

AN International Congress for Logic, Methodology and Philosophy of Science will be held at Stanford University, California, during August 24–September 2, under the auspices of the International Union for History and Philosophy of Science. Further information can be obtained from Prof. Patrick Suppes, Serra House, Stanford University, Stanford, California.

THE fifth International Congress on Nutrition will be held in Washington, D.C., during September 1–7, and will be organized under the auspices of the International Union of Nutritional Sciences, the American Institute of Nutrition and the U.S. National Committee, International Union of Nutritional Sciences of the National Academy of Sciences–National Research Council. Further information can be obtained from the Secretariat of the Congress, 9650 Wisconsin Avenue, Washington 14, D.C.

THE Extra-mural Department of the University of Manchester, on behalf of the Department of Physics of the Manchester College of Science and Technology, is holding a summer school in Modern Methods of Crystal Structure Determination during August 29–September 9. The school has been arranged to follow the meeting in Cambridge of the International Union of Crystallography. Further information can be obtained from Prof. H. Lipson, Manchester College of Science and Technology, Sackville Street, Manchester, 1.

INTERNATIONAL ASSOCIATION FOR THE PROTECTION OF INDUSTRIAL PROPERTY

THE International Association for the Protection of Industrial Property held its twenty-fourth congress in London during May 30–June 4. It cannot be said to be a widely known Association, for although the work with which it is concerned, namely, international rights in patents for inventions, trade marks and industrial designs (called 'industrial property' as distinct from 'intellectual property', which is rights in artistic and literary copyright), is the very life-blood of an industrial and manufacturing country such as Britain, public interest in the maintenance of these rights abroad is virtually nil. Nevertheless, the lively interest and vigilance of the few who recognize the trading, economic and financial importance of these rights makes up for the public indifference.

Members of the Association (often known as A.I.P.P.I. from the French form of its name) are professional men and industrialists, such as patent lawyers, and executives of firms with considerable rights in this field arising from research. The Association, which was founded in 1897, works in close harmony with the Bureau of the Industrial Property Union set up by a multilateral treaty known as the Paris Convention of 1883. This Convention (which is the most important international treaty in the patent and trade mark field) was founded and agreed because of the multitude of difficulties confronting a manufacturer of any country who wanted to protect his inventions or trade marks abroad. Indeed, before the Convention was signed, the task of obtaining such protection was almost impossible. The Convention laid down agreed principles which were made law in the signatory countries, whereby reciprocal treatment in obtaining rights for patents and trade marks were given to the nationals of these countries. At present forty-seven countries are members of the Union. The original Convention has been revised at diplomatic conferences held in Brussels in 1900, in Washington in 1911, in The Hague in 1925, in London in 1934, and in Lisbon in 1958.

The Association now has about 2,300 members all over the world. Countries where there are a large number of members form national groups, with an elected president, council, secretary and treasurer. There are now nineteen such groups. Its primary work is to improve the terms of the Convention and its operation in practice by suggesting, through the Bureau of the Industrial Property Union at diplomatic conferences, amendments in the law and practice relating to industrial property in all countries. Such an object can only be achieved gradually, and in a changing world the effort must be continuously sustained. Already many improvements have been made as a result of the Association's work. It is true to say that nearly all the proposals put forward for consideration and adopted by the diplomatic conferences referred to above have been the result of the work of unofficial bodies such as the Association and the International Chamber of Commerce, consisting as they do of specialists in the industrial property field who are constantly, in their day-to-day work, encountering the difficulties and problems created by international manufacturing rivalry, and who, by their experience and special knowledge, are best able to suggest remedies.

The officers of the national groups meet several times each year at various international centres, and the Association discusses the problems arising at congresses held in alternate years, different countries acting as hosts. Since the War, the Association has held congresses at The Hague (1947), Paris (1950), Vienna (1952), Brussels (1954), Washington (1956), Stockholm (1958), and now London (1960). The previous congresses held in London were in 1898, 1912 and 1932. Prior to the Second World War, the congresses were rather small affairs, but international interest in industrial property has grown so considerably that attendance and the number of countries interested have increased greatly. At the recent congresses, about 600 delegates have attended, with their ladies. In London, the number increased still further to about 700 and the total of participants (including ladies) was more than 1,400, representing thirty-eight countries. There were representatives from the Governments of sixteen countries, five intergovernment organizations and four international associations. The Government representatives were mostly heads of national patent offices and ministries corresponding to the Board of Trade in Britain.

The London Congress was held under the patronage of H.R.H. Prince Philip, and under the presidency of Sir John Hanbury-Williams.

At the working sessions, held in St. Pancras Assembly Rooms, simultaneous translation of papers in English, French and German was arranged. The following problems were discussed: termination of rights to register trade marks owing to non-use; cancellation of the registration of a trade mark at any time upon proof of abandonment; trade marks or trade names with extended protection; suppression or limitation of trade mark rights after a certain period of use; revocation of patents for non-working; effects on industrial property rights of national and international rules providing for free competition; competence of arbitrators and enforcement of their awards in matters of contracts relating to industrial property; method and preparation of a study of the unification of patent laws; restrictions of the right of the patentee for reasons of public interest; temporary protection at exhibitions; extension of periods expiring on a public holiday; international protection of works of applied art, designs and models; revision of the "Arrangement" of The Hague concerning the international deposit of industrial designs and models; licensing of trade marks; translation of trade marks.

All these problems were fully and freely discussed by the delegates, and in due course the recommendations of the Congress on them will be published and submitted to the Bureau of the Industrial Property Union for the next diplomatic conference, which, so far as The Hague "Arrangement" for industrial designs and models is concerned, will be held at The Hague in November next.

On the social side of the congress week, the inaugural ceremony of its opening was held at the

Royal Festival Hall on May 30, presided over by the Lord High Chancellor, the Right Hon. the Viscount Kilmuir; on May 31, a Government reception was held at Lancaster House under the auspices of the Board of Trade, which was also attended by Prince Philip; on June 2 the delegates attended a gala performance of "The Barber of Seville" at the Royal Opera House; and on June 3 the closing banquet was held in the Great Hall of the Royal Courts of Justice (by permission of the Lord Chancellor and the Minister of Works), followed by a ball in the Halls of the Middle and Inner Temples (by permission of the Benchers of the Middle Temple and Inner Temple).

In consequence of the earnest representations of the German Group, it was agreed that the next Congress of the International Association for the Protection of Industrial Property be held in Berlin in 1963. The Japanese Group also made strong representations that the Congress following the Berlin one be held in Tokyo in 1966, especially as the Association has never yet met in Asia. In view of the decision to hold the next Congress in Berlin, an invitation was sent to Peter von Siemens, of Werner von Siemens, Erlangen, to succeed Sir John Hanbury-Williams as president.

The permanent officers of the International Association are: *Secretary-General*, Eugène Blum; *Assistant Secretary-General*, Dr. Rudolf Blum, of Zurich, the headquarters of the Association; *Reporter General*, M. Paul Mathely (Paris); and *Treasurer General*, M. Jaques Bede (Brussels). The president of the British Group is Mr. G. W. Tookey, Q.C., the joint secretaries, Mr. Michael Hesketh-Prichard (chartered patent agent) and Mr. Martin H. Lowry (solicitor), and the treasurer Mr. L. A. Ellwood (solicitor). The president of the German Group, which will be responsible generally for the organization and running of the next Congress, is Herr H. G. Heine (patent agent), and the secretary, Herr Moser von Filseck (advocate).

H. C. MILLER

PARASITES AS ENEMIES AND ALLIES

THE Spring Meeting of the Parasitology Group of the Institute of Biology was held during April 6–8 in the new buildings of the Liverpool School of Tropical Medicine, by kind arrangement with Prof. W. E. Kershaw. This was the second annual meeting of its kind, and was attended by about a hundred biologists with widely differing interests in parasitology.

Twenty offered papers were concerned with a variety of disciplines and of animal parasites, ranging from studies on the biology of the tapeworm larva, *Cysticercus bovis* (P. H. Silverman), to mitochondrial enzymes in relation to malaria (B. G. Maegraith) and a mathematical analysis of populations of helminths in wild and domesticated animals (H. D. Crofton). The invited speaker, Prof. T. H. Davey, surveyed the role and status of parasites in his discourse on "Parasites as Enemies and Allies".

In the rapidly developing field of physiology of parasites, R. L. Muller presented his experiments on glycogen metabolism in *Haplometra cylindracea* and showed this fluke to be an obligate aerobe—a nice correlation with its habitat in the lung of the frog. Investigations into the growth patterns of certain tapeworms, undertaken by C. A. Hopkins, revealed that during growth the plerocercoid larva doubles its weight every 24 hr., and that it becomes infective before reaching its maximum size. Under the stimulus of transmission to the definitive host, exponential growth is resumed until maturation of the worm. Hopkins suggested that at maturation a growth-inhibiting substance is produced which, because of linear growth and the lack of a circulatory system, does not affect the anterior region of the worm. The proteolytic activity of extracts prepared from *Entamoeba histolytica* and the optimum conditions for proteolysis were reported by R. A. Neal.

Histochemical studies included the distribution of nucleic acids in normal and in akinetoplastic strains of *Trypanosoma evansi* by J. R. Baker. D. L. Lee showed that the ovijector of *Thelastoma bulhoesi*, a nematode inhabiting the hind-gut of the cockroach, secretes a mucoprotein responsible for the sticky covering of the eggs. Certain aspects of the behaviour of parasites were treated by F. Hawking and M. J. Worms, who described responses of microfilaria counts of *Monnigofilaria setariosa* to external stimuli applied to the host, the mongoose, and who discussed reasons for the periodic migrations of microfilariæ into the peripheral blood.

A knowledge of the life-cycle of a parasite is fundamentally important to epidemiological studies of parasitic diseases, and work by T. E. Gibson on the development of eggs and larvæ of two species of sheep nematode, *Nematodirus battus* and *N. filicollis*, and on pasture population densities has allowed grazing management methods to be devised which enable complete control of the disease. The density of parasite populations is also important in the case of ducks harbouring the acanthocephalan *Polymorphus minutus*, which under certain conditions can cause serious losses, and H. B. N. Hynes gave an account of the way in which the parasite spreads by means of its intermediate host, *Gammarus* spp., from an infected flock penned on to a small stream.

An example of how a population of parasites may serve as an indicator of different zoogeographical populations of host was illustrated by Z. Kabata. Whiting inhabiting the North Sea to the north of the Dogger Bank harbour abundant *Ceratomyxa* in the gall bladder, whereas fish to the south are infected with *Myxidium*. There are also differences in the myxosporidian fauna of these fish from the Faeroes and of the haddock from these areas.

Parasitic infections may evoke immune reactions in the host, and this host-reaction can be utilized to test for the presence of the parasite. R. J. Terry, D. Poynter and P. H. Silverman reviewed and appraised the value of various hæmatological and serological techniques employed in diagnostic tests. Further uses of host-reaction in detecting the presence of a parasite were reported by S. F. M. Davies and L. P. Joyner, who found that in chicks with a sub-lethal

infection of the coccidian *Eimeria tenella*, the measurements of the resultant anæmia provided a more sensitive means of detecting the parasite than do observations on the growth-rate of the chicks. In *E. necatrix* infections, however, there is a marked reduction in the growth-rate accompanied by only mild anæmia and the infections may thus be readily distinguished.

A host animal may show resistance to infestation by parasites, and J. F. Michel showed that resistance of the rabbit to the nematode, *Trichostrongylus retortaeformis*, may be manifested by the elimination of the adult worms, by arrest of development of the worms at the third larval stage or by preventing a new infestation from becoming established. The spontaneous elimination of parasites from the host known as self-cure also occurs in sheep infested with the nematode *Haemonchus contortus*. E. J. Soulsby investigated the serological reactions which take place at self-cure using complement fixation, hæmagglutination and Ochterlony agar diffusion precipitin techniques. The evidence indicates that at this time there is a marked immunological response and that the main antigenic stimulation is from substances released by larvæ undergoing the third moult.

The susceptibility of a host to infestation may be influenced by the presence of other parasites already established in the host, and the nature of the interaction between such intercurrent infestations was studied by J. E. D. Keeling in rats experimentally infested with *Nippostrongylus muris* and *Strongyloides ratti* and mice with *Aspicularis tetraptera* and *Trichuris muris*. The susceptibility of plant hosts to attack by animal parasites is different from that of an animal host, and differences between varieties of chrysanthemum in susceptibility to attack by eelworms were discussed by H. R. Wallace. The behaviour of eelworms on the outside of the plant, the invasion of the leaves through the stomata and movement of the worms within the leaf were described. The evidence supports the theory that varietal variation in susceptibility is related to hypersensitivity of the leaf tissues to eelworm invasion.

The degree of host-specificity shown by a parasite may be important in the epidemiology of human disease, as in the case of a pathogen harboured by both man and his domestic animals. F. E. G. Cox posed the question, "Is *Balantidium coli* a zoonosis?" and presented data suggesting that this protozoan normally found in pigs is not, contrary to common belief, easily acquired by man except possibly in certain nutritionally deficient states. Another group of protozoans, the 'Limax' *Amœbae*, have frequently been reported as parasites of both invertebrates and vertebrates, including man, and they are also abundant in the soil. Although these animals are similar morphologically they show great differences in their physiology and micro-anatomy and these differences are reflected in the ecology of the individual species. K. Vickerman submitted evidence that some of these 'Limax' *Amœbae* are facultative parasites closely related to soil-occurring forms, whereas others are obligate parasites more closely resembling the Endamoebidae.

A group of short papers and demonstrations described the work in progress at the Liverpool School of Tropical Medicine, and these together with three other laboratory demonstrations concluded the meeting. The proceedings of this meeting will not be published in full.

J. Mahon

GLASSHOUSE CROPS RESEARCH INSTITUTE

THE Glasshouse Crops Research Institute, Littlehampton, Sussex, held its annual open day on May 17, more than four hundred visitors attending. The laboratories were open for inspection during the morning, and many visiting research workers and growers availed themselves of this opportunity to see the work in progress and to discuss aspects of it with the Institute's scientific staff. After lunch, the director, Mr. F. W. Toovey, gave a brief report to the assembled guests and visitors on the development of the Institute over the past year and on future plans, and directed attention to some lines of work of particular interest and importance. During the afternoon a number of special demonstrations were arranged in the experimental glasshouses and mushroom sheds.

In the tomato-breeding programme undertaken by Mr. L. A. Darby, the introduction of the even-ripening character of the 'Stonor' varieties into two well-known standard varieties, 'Potentate' and 'Ailsa Craig', was shown. The object of this is to eliminate the ripening disorder commonly known as 'greenback'. A parallel breeding programme has produced plants which have the compact habit of 'Baby Lea' but with the truss, fruit size and shape, and the freedom from 'greenback' of 'Moneymaker', the best-known of the 'Stonor' varieties. The new types have yet to be tested for yielding ability, but it is hoped they will prove valuable to the grower as a means of producing better quality fruit.

The main variety trials were concerned with the further evaluation of selections descended from hybrids with the compact-habit (short internode) 'Baby Lea' variety, and include some which have attracted a good deal of interest among growers. Some of this material is being subjected to wide screening on growers' holdings and experiment stations this year.

Of interest in connexion with the tomato-breeding programme and other work at the Institute was a demonstration by the statistician (Mr. D. Cooke) of the results of a survey carried out in 1959 of the varieties of tomato grown commercially. From a 10 per cent sample of growers seventy distinct varieties were recorded, the four most commonly grown, according to total acreage, being 'Moneymaker', which occupied 32 per cent of the 2,067 acres estimated to have been grown in Great Britain in 1959, 'Potentate' (17 per cent), 'Ware Cross' (15 per cent) and 'Ailsa Craig' (6 per cent). Within this general pattern, however, there were marked differences according to district and time of planting.

The Chemistry Department, under Dr. G. W. Winsor, demonstrated some aspects of its work on plant nutrition, composition and biochemistry. The nutrition trials now cover the tomato, carnation,

lettuce and early-flowering chrysanthemums, and the Department is closely associated with studies on bulb nutrition at the Ministry of Agriculture's Experimental Husbandry Farm at Kirton, in Lincolnshire. The special demonstration for the day was on the subject of carnation nutrition, the first experiment, extending over two years, having just been completed. This factorial trial, testing three levels of nitrogen and two of potash in the presence or absence of added phosphate, magnesium or calcium, making forty-eight different combinations of fertilizer treatment in all, showed a beneficial response to phosphate and nitrogen in terms of total flower production, and splitting of the calyces was more marked at low nitrogen-levels. A more complete assessment of the results will be possible when the numerous soil and tissue samples taken during the course of the experiment have been analysed. Visitors were able to see the second experiment on this subject which had just been planted; this is another factorial trial comprising four levels of nitrogen and three levels of potash supplied in liquid feeds, superimposed on four levels of phosphate and two levels of lime incorporated in the planting compost.

Other subjects dealt with by the Chemistry Department were the problem of manganese toxicity and the effect of soil salinity on plant growth. Symptoms of manganese toxicity had been observed on tomato, carnation and lettuce, and the disorder appears to arise when considerable amounts of soluble and exchangeable manganese are released from glasshouse soils sterilized by steaming. For the soil salinity studies a reliable and convenient method for the fairly rapid determination of salt concentration in the presence of sparingly soluble salts such as calcium sulphate, which commonly accumulate in glasshouse soils, is being sought.

The Chemistry Department is devoting a good deal of attention to studying the composition of tomato fruit. Rapid methods have been developed for the analysis of relatively large numbers of fruit samples, and much information is being accumulated on the relation between fruit composition and manurial levels, variety and environmental conditions. Special attention is being paid to the problems of fruit quality in relation to fruit composition, and it is hoped that the information being obtained will serve as the basis of an approach to the problem of fruit flavour. Although there is much still to be learned as to the primary cause of fruit disorders, such as 'blotchy ripening', it is clear that their development ultimately depends on some departure from the normal biochemical processes of fruit ripening. Studies of certain enzymic processes in tomato fruit have therefore been undertaken, starting with the pectic enzymes associated with the softening of tomato fruit during ripening. Limited exploratory work on the effects of ripening of certain enzyme inhibitors injected into tomato fruit is also in progress, the object being to gain some insight into the mechanisms by which rates of ripening are controlled in the fruit.

The environmental factors which influence ripening disorders in the tomato fruit have also been investigated by the Plant Physiology Department, under Dr. E. R. Leonard, and experiments were shown in which the effects of subjecting fruit tissues to different levels of temperature, while the plants remain at house temperature, were being studied with particular reference to fruit coloration.

Work on the growth of the tomato has been carried a stage further, and plants were seen growing in glass chambers in which the environment, including day-length, is partially controlled. Weekly measurements of roots, stems, leaves and fruit were being made on these plants, as well as daily counts of anthesis. In an accompanying experiment the relation between growth and development of tomato plants and the age of the plant and time of year was being further investigated, with special reference to the development of the first truss.

Work on virus diseases was a particular feature of displays by the Plant Pathology Division, under Dr. L. Broadbent. A number of diseases of flowers and ornamentals which are being studied were demonstrated, as well as attempts to free stock plants of chrysanthemum and carnation from virus diseases by heat therapy or meristem culture. The investigation of tobacco mosaic virus on the tomato, a serious problem to the grower, has been intensified, and several critical experiments on various aspects of the problem were in progress. Special attention is being paid to the sources of infection in commercial glasshouse practice, and experiments are being carried out to determine the relative importance of seed, infected residues in the soil, infected structures and tools, infected clothing and smoking tobacco. An attempt is also being made to assess the loss from infection under glass, using a moderately severe strain of tomato mosaic virus inoculated into two varieties, 'Potentate' and 'Moneymaker', at three stages in plant growth. The experiment was planted in mid-February, and by the open day there were marked differences in growth and fruit set between early-infected plants and the remainder, all the inoculated plants being still healthy.

Also within the programme of the Plant Pathology Division was a demonstration of the work on the 'watery stipe' disease of the cultivated mushroom, undertaken in the Mycology Department under Mr. P. H. Williams. Recent experiments have shown beyond doubt the transmissibility of this disease, and the infective principle in a diseased mycelium, which is always characterized by abnormally poor growth, can be passed to a healthy one simply by growing the two together. The further finding that infectivity can be eliminated from diseased cultures by a process akin to heat therapy raises the intriguing possibility that a virus may be responsible for the mushroom disorder, and virological techniques are being employed with the view of finding out if this is so.

Other work on cultural aspects of the mushroom is undertaken by the Horticultural Department under Mr. G. F. Sheard, and specially constructed chambers for studying the effect of environmental conditions on fruiting and development of the mushroom were on view. In these chambers, of which there are eight, each with 4 sq. ft. of growing area, temperature, relative humidity and ventilation-rate can be varied independently.

Among crop protection problems under study was a comparison of chemical soil sterilizing agents, including the newly introduced metham–sodium (sodium methyldithiocarbamate), with the traditional steaming method. This experiment has shown that on a soil free from serious soil-borne diseases, yet needing sterilizing to restore fertility, chemicals can be as effective as steaming, treated plots giving about a 20 per cent increase in crop over the untreated controls. The long-term effects of repeated applications of

chemicals need to be studied, however, and the distribution of the chemicals in the soil, their breakdown and possible phytotoxic effects are being investigated in the laboratory.

The problem of resistance to acaricides shown by the glasshouse red spider mite (*Tetranychus urticae* Koch), which is assuming serious proportions in the Lea Valley on cucumbers, is being tackled as a co-operative project by the Crop Protection Department, under Mr. W. H. Read, and the Entomology Department, under Dr. N. W. Hussey. This work involves the testing of Lea Valley strains of the mite for cross-resistance to other acaricides to assess the practicability of increasing the range of materials in use. This is to be followed by large-scale trials later this year to investigate control of the pest by physical and biological agencies to which it is unlikely to develop resistance.

F. W. Toovey

SCIENCE TEACHING IN SECONDARY MODERN SCHOOLS

SERIOUS deficiencies in the provision of science teachers, laboratories and science equipment in many secondary modern schools are revealed in the results of a survey carried out by the Science Masters' Association. Three-quarters of the nation's children attend secondary modern schools, yet in many of them serious shortages are revealed. Many schools returned the questionnaire stating that they provided no teaching in science, 73 taught no science because there were no teaching facilities, 33 because there were no teachers available who were capable of teaching science.

The material on the survey was collected from more than 1,500 questionnaires. The return compared with a total of about 3,700 schools of this type existing in 1958; the investigation was conducted throughout by the Secondary Modern Schools' Committee of the Science Masters' Association.

The Committee believes that there should be one laboratory for each 300 pupils in the school, two for schools of 301–600 pupils, and three for those of more than 600. The survey states that on investigating the conditions under which science was being taught in secondary modern schools, 47 per cent are obliged to teach all or part of their science under unsatisfactory conditions.

The investigation revealed that only one science teacher in six in a secondary modern school is a graduate, while about one in six has "no pretensions at all to science qualifications". Only 34 per cent of the schools considered that they were adequately staffed for teaching science. Special account is taken in the survey of head teachers' opinions on the most important needs to improve science teaching. Their orders of priority are more science teachers, more laboratory accommodation, and more equipment.

The statistical return suggests that, in 65 per cent of the schools concerned in the survey, more science staff are needed. The booklet comments: "It follows that in the country as a whole no fewer than 2,500 schools need science teachers and in some cases more than one teacher will be required".

Copies of the booklet are available, price 1*s.*, from Mr. D. M. Chillingworth, The Village College, Swavesey, Cambridgeshire.

SCIENTIFIC RESEARCH IN EAST AFRICA

JUST over half the annual report of the East Africa High Commission for 1959 deals with the East African Research and Scientific Services, on which some £706,466 was expended, with a further £212,962 on the Desert Locust Survey, £270,812 on the Meteorological Department and £470,645 on the Directorate of Civil Aviation, out of a total recurrent expenditure in 1958–59 of £3,907,933, towards which £567,863 was received from the United Kingdom Government in Colonial Development and Welfare or direct Exchequer grants*. Some account of the work of these regional organizations, for example the East African Agriculture and Forestry Research Organization, the Veterinary Research Organization, the Fishery Research Organization and the Institute for Medical Research, was included in the reports published under the title "Colonial Research 1958–59", but no reference was made in that report to the curtailment of research programmes through the reduction of scientific staff at some of the High Commission's organizations in consequence of territorial financial cuts. The East African Agriculture and Fisheries Organization report, for example, refers to the reduction of the establishment of research officers from 28 to 23 and of scientific assistants from 20 to 14, chiefly in the Divisions concerned with soil fertility, soil chemistry and soil classification, with the result that the Organization is not always able to co-operate effectively with the Territorial Departments. The Trypanosomiasis Research Organization also refers to reduction in staff, and the Meteorological Department has found the difficulty of recruiting staff from Britain to constitute a formidable obstacle in its programme of expansion. On the other hand, help is being received from the Rockefeller Foundation for agricultural research in East Africa, and the Nuffield Foundation is financing further research on the physiology of drought resistance in crops, and on the improvement of the nitrogen status of tropical soils by suitable use of indigenous tropical legumes.

The work of the Agriculture and Forestry Research Organization has included work on the increase of crop-yields by reducing the damage done by pests and diseases, such as the study of 'stem pitting' of *arabica* coffee, a survey of the nematodes of the principal East African crops, the development of a strain of maize resistant to the virus disease known as 'streak', and also work on the effect of drought on the growth of plants and the water requirements of

* East Africa High Commission. Annual Report, 1959. Pp. iv + 100. (Nairobi: Government Printer, 1960.) Sh. 5.

irrigated crops. Forestry research also has been concerned with the effect of forests on water supplies, as well as the best methods of raising seedling trees in the nursery and for planting out in the forest, and the protection of East African forests against insect attack, particularly by timber borers, and the use of ultrasonic and gamma-radiographic techniques to detect attack and to measure the severity of attack are being examined. In the Veterinary Research Organization, the Division of Virus Diseases achieved interesting and important results in its investigation of rinderpest. Good progress was made in research on swine fever, and work on East Coast fever continued; but the work of the Division of Bacterial Diseases was hindered by shortage of staff.

The reorganization of the East African Trypanosomiasis Research Organization is well advanced, and all research disciplines are being concentrated at Tororo in Uganda. Studies on the trypanosomes are being developed mainly towards an understanding of immunology and the routine testing of new drugs for cattle prophylaxis is now to be the concern of the Territories, and the Research Organization is recruiting workers for fundamental studies on drug resistance. The Marine Fisheries Research Organization continued its work on tuna longlining and the North Kenya banks survey, and an investigation of the potential prawn fishing of the estuarine waters of Tanganyika was commenced.

The Pare–Taveta malaria scheme of the East African Institute of Malaria and Vector-borne Diseases, which ended in June 1959, has shown that malaria transmission can be reduced to a very low level but not completely arrested, as a result of four years residual spraying of houses, in an area of hyperendemic malaria. The dispersion and longevity of *Anopheles gambiae* were studied mainly by introducing radioisotopes into the larval breeding pans. The completion of the 120-ft. steel tower in the Mpanga forest enabled the Virus Research Institute to expand considerably its work on the biology of mosquitoes and other blood-sucking flying insects, and the analysis of data collected over the past fifteen years indicates that while in some species of mosquito the biting pattern is uniform over a very wide area, in others the pattern varies according to locality, environment or even level in the forest. The East African Leprosy Research Centre commenced a therapeutic trial of 'Etisul', and surveys of leprosy clinics in Uganda and Kenya confirmed the low proportion of true lepromatous cases.

The East African Industrial Research Organization completed its projects on the mechanical drying of coffee and on the control of arsenic in the production of cement copper. The Meteorological Department continued its investigation on the use of cetyl alcohol to reduce evaporation from water surfaces, and a two-year programme of forecasting research was commenced in June 1959 to gain knowledge of the rain-producing agencies operative in East Africa and the improvement of weather forecasting generally. Progress is being made in the study of the strong winds which occur at high levels in tropical and subtropical latitudes. The Desert Locust Survey reports on control operations against swarms in the Somaliland Protectorate, January–June 1959 and July–October 1959, and in Turkana, April–May 1959, and on campaigns against hopper of the short-rains generation in the Somali peninsula conducted in the Ogaden. Reference is made in the report to the problems created for the Directorate of Civil Aviation by the introduction of jet airliners and to the difficulty of recruiting suitably trained and experienced officers capable of maintaining standards.

SUICIDE: A NEGLECTED PROBLEM

THE incidence of suicide is on the whole low in the less-developed countries, high in the more; and in some countries of very high living standards it has become a problem of considerable proportions. Between the ages of fifteen and forty-four it is the second most important cause of death in Japan, the third in Germany, Denmark, Sweden and Switzerland, and the fourth in Canada, Australia and the United States. It is also an important cause of death between the ages of forty-five and sixty-four*.

In the United States some 16,000 people commit suicide every year, as compared with 14,000 who die from tuberculosis and 40,000 who die from motor accidents; in England and Wales the number of suicides, approximately 5,000 annually, is nearly as great as the number of those who die from pulmonary tuberculosis, and slightly exceeds the number who die from motor accidents. More men commit suicide than women, and, as age increases, the preponderance of male suicides becomes greater.

Durkeim, in his classic study of suicide, divided suicide into three types: the altruistic, in which the individual's life is rigorously controlled by the customs and beliefs of a rigid society, and who commits suicide for religious or political reasons; the egoistical, in which he is insufficiently integrated into society; and the anomic, in which he is insufficiently regulated by society and his adjustment may be upset by economic catastrophes or sudden wealth.

Inherent disposition plays an important part in suicides. The stresses of loneliness and friendlessness act with selective severity on those predisposed to mental illness, and these are often the individuals who commit suicide. Cause and effect are not easy to distinguish. Do individuals, for example, who commit or attempt to commit suicide drift into isolated environments because of the illness that drives them to take their own lives, or are certain environments conducive to suicidal tendencies? Alternatively, is loneliness both a consequence of mental ill-health and a factor increasing the chances of suicide? The whole problem of suicide is extremely complex; the causes are not well understood.

Statistical data about suicide are among the most clear-cut epidemiological facts in the whole field of psychiatry, and should lend themselves to intensive inquiry. It might then be possible to understand more clearly why there are striking differences in incidence between the more-or-less developed countries, between communities of different religious denominations, and between urban and rural areas. It should then be possible to prevent attempts at suicide, and provide those who attempted but failed with efficient after-care or social support.

* *WHO Chronicle*, **14**, No. 5 (May 1960).

ALPHA ACTIVITY OF CERTAIN BOTANICAL MATERIALS

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THE data presented in this article result from continuation of a series of investigations aimed at defining the nature and present levels of naturally occurring radioactivity in man and his environment[1–5]. Previously we have been concerned with the direct intake of natural radioactivity by man, and this has led inevitably to studies of the activity of foods and waters and to the study of a range of plant and animal material. We have demonstrated the great variations in levels of radioactivity to be found in different foods and this has now led us to make measurements of a number of plants, some of which are used directly as human foods while others, such as grasses, form the principal food of animals, which in turn themselves become human food.

Knowledge of the natural alpha activities of plants has become important from another point of view connected with the siting of nuclear installations. The importance of early detection of any emission of radioactive material from such sites demands that the levels of natural activity in the neighbourhood be adequately defined prior to the commencement of operation. Furthermore, in defining these initial levels it must be possible to identify the alpha-emitting materials present, and to be able to differentiate between the natural radioactivities due to the radium and thorium series and that due to artificially produced alpha emitters such as plutonium-239.

We have found this investigation of plant materials one of very great complexity, and from a large mass of experimental observations we have therefore selected data illustrating the possible answers to one or two fundamental questions.

The measurements of total alpha activity, the assessments of the relative contributions made by the uranium and the thorium series and the precise identification of the nuclides present have been carried out using techniques previously reported[1,6]. A number of the sets of soils, matts and grasses were essay samples obtained via the Radiobiological Laboratory of the Agricultural Research Council. These grasses were provided in the form of specimens of mineral ash resulting from muffle furnace treatment of the original material at 550° C. some months previously. Other sets of soils, fruit and vegetation were provided by the Westminster Hospital Medical School Expedition to Central Africa in 1958. This material comprised specimens of fruit, leaf, twig, bark and root from a number of species together with the corresponding samples of soil. The fruit and vegetation samples were reduced to ash at 650° C. and serial measurements spread over many months made on the ash.

The soils and the matts have been measured in the raw state, although selected specimens have also been ashed and the ash activities compared with the values for the raw materials, again over long periods of time subsequent to ashing.

Study of the reduction, produced by ashing, of alpha activity due to the uranium series and of the rate of recovery of this activity during the succeeding months has provided valuable information as to the presence of specific members such as lead-210 and polonium-210 in many of the matt and vegetation specimens. Further evidence of the presence of polonium-210 has been provided by an alpha-ray spectroscopic technique[6]. Serial measurements have, in addition, provided evidence of growth of alpha activity due to the thorium series in numbers of the specimens of vegetation.

Measurement of more than fifty specimens of soils, sands and chalks from different parts of Great Britain and from Central Africa revealed values of total alpha activity ranging over a factor of only 5 to 1 for soils and about 8 to 1 for sands.

Table 1 lists the values found for a few selected specimens including the maximum and minimum activities so far observed in each category. Assuming that radioactive equilibrium exists in both series, the soil uranium contents range from 0·5 to 2·3 and the thorium contents from 0·6 to 3·0 μμc./gm. soil.

Table 1. Soil Activities in μμc./gm. Raw Soil

Ref.	Origin	T.A.A.	U-238	Th-232	Th/U
9	Central Africa	20·6	1·4	1·6	1·1
11	,, ,,	25·2	1·5	2·2	1·5
14	,, ,,	26·2	2·2	1·5	0·7
22	,, ,,	11·1	0·7	0·9	1·3
23	,, ,,	28·8	1·5	2·8	1·9
24	,, ,,	13·7	0·2	2·0	10·0
27	,, ,,	15·6	1·1	1·1	1·0
28	,, ,,	19·8	1·6	1·2	0·8
29	,, ,,	21·2	1·9	1·0	0·5
30	,, ,,	18·1	1·5	1·0	0·7
31	,, ,,	28·4	1·3	3·0	2·3
*SA*1	Wales	13·0	0·4	1·7	4·2
*SA*4	,,	11·0	0·3	1·4	4·7
*SA*6	Devon	36·0	2·3	3·0	1·3
*SA*9	Scotland	7·7	0·5	0·6	1·2
*SA*12	Ireland	11·0	0·5	1·2	2·4
*SA*22	Berkshire	15·5	0·9	1·3	1·4
	Cornwall	20·0	0·8	2·3	3·0
	Cornwall	10·0	0·4	1·1	2·5
Sand 1	Isle of Wight	6·0	0·4	0·4	1·0
Sand 2	Cornwall	50·0	2·5	5·0	2·0
Chalk 1	Surrey	0·9	0·06	0·06	1·0
Chalk 2	Kent	0·8	0·07	0·04	0·5

The values observed for chalks are relatively much lower, with little difference between specimens of different origin.

Six months or so after sealing the soil samples the majority showed small increases of 5–6 per cent in their alpha activities, presumably due to reduction of loss of radon and hence to a slight build-up of radon and the later members of the uranium series.

The specimens of raw matt showed initial values of total alpha activity ranging from 8 to 28 μμc. per gm. a few days after sealing, but in the subsequent months marked differences were observed between the behaviour of the various samples.

Table 2. Activities of Raw Matts in μμc./gm.

Ref.	Origin	T.A.A.		U-series		Th-series	
		$t=0$	$t=100$	$t=0$	$t=100$	$t=0$	$t=100$
*SA*1	Wales	13·0	13·0	4·8	—	8·4	—
*SA*4	Wales	11·0	12·3	9·4	10·5	1·8	1·8
*SA*6	Devon	28·0	31·1	15·0	18·1	13·0	13·0
*SA*12	Ireland	9·4	9·4	4·0	—	5·4	—
*SA*23	Berks	8·0	10·4	3·7	6·1	4·3	4·3
*SA*24	Berks	8·2	12·2	5·3	6·6	2·9	5·6

Table 2 gives the values of alpha activity and the relative contributions from the two natural series observed in a few of the specimens at time $t = 0$ (soon after sealing the sample) and 100 days later. Three types of behaviour are illustrated.

In samples *SA*1 and *SA*12 no change was observed in their activities after 100 days, whereas in *SA*4, *SA*6 and *SA*23 the total alpha activities rose, due to increased activity of the uranium series with the contribution from the thorium series remaining unchanged. In *SA*24 there is increased uranium series activity and an even more striking rise in activity due to the thorium series. Evidently the matts may have either or both of the two natural series in a state of radioactive equilibrium or disequilibrium, and the alpha activity of any particular specimen may vary appreciably with time after sampling.

An aliquot of *SA*4 matt showing increased uranium series activity with time was reduced to mineral ash in a muffle furnace and a series of measurements carried out on the ash during the following twelve months.

Table 3 summarizes the results of these observations. A concentration of 7·26 times was achieved by ashing, and the figures for the raw matt activity in column 4 have been derived by dividing the values of ash activity in column 3 by this factor. Column 2 gives the values observed directly on the raw matt sample.

Table 3. Recovery of Matt Activity after Ashing Specimen *SA*4

Days after sealing	Total alpha activity μμc. per gm.		
	Raw matt by direct measurement	Matt ash	Raw matt value from ash value and concentration
0	11·0	13·6	1·9
28	11·5	24·0	3·3
100	12·3	43·0	5·9
150	—	53·0	7·3
335	12·5	64·6	8·9

It will be seen that immediately after ashing the estimated alpha activity of raw matt as deduced from the ash value (column 4) was only 17 per cent of the value observed directly (column 2) for the raw matt. After 28 days when the radon, radium *A* and radium *C′* lost in the ashing process have recovered to equilibrium with the radium-226 present, the ash activity is still only 29 per cent of the expected value. The ash activity continued to increase and is still rising after 335 days from the time of ashing.

Using the ash activities of column 3 and assuming that the increase in alpha activity after 28 days is due to the growth of a single alpha emitter, it is easy to calculate that the half-life of this emitter would be about 150 days and we deduce that the nuclide concerned is almost certainly polonium-210. If this is the case, the final value which will be reached by the polonium-210 can be shown to be 78·0 μμc. per gm. ash and the equilibrium total alpha activity to be 92·7 μμc. per gm. ash. This latter figure corresponds to a raw matt activity of 12·8 μμc. per gm., which has very nearly been reached by the direct measurements on the raw matt given in column 2.

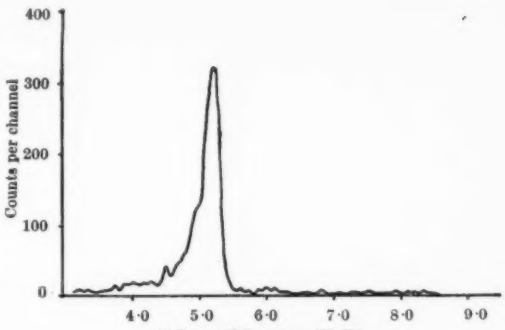

Fig. 1. Alpha-ray spectrum of *SA*4 matt ash

Furthermore, the constant portion of the activity of the ash after 28 days can be shown to be 14·7 μμc. per gm., of which 2·9 μμc. is due to radium-226. Hence the radium *D* (lead-210) content of the matt is a factor of 78·0/2·9, that is, 27 times higher than the radium-226 level.

In other words, 84 per cent of the alpha activity of this matt specimen is apparently due to the single nuclide polonium-210 existing in or near equilibrium with its parent lead-210, which itself is present at a much higher level of activity than radium-226.

Fig. 1 shows the alpha-ray spectrum of this particular matt ash and clearly indicates that a single alpha emitter is responsible for the majority of the activity and that its energy is approximately 5·3 MeV., the energy of the polonium-210 alpha particle.

Table 4. Grass Ash Activities in μμc./gm. Ash

Ref.	Origin	T.A.A.	Ra-series	Th-series
*SA*1	Wales	9·6	5·6	4·0
*SA*6	Devon	11·0	8·2	2·8
*SA*9	Scotland	21·0	16·0	5·0
*SA*12	Ireland	9·7	6·4	3·3
*SA*22	Berks	1·1	0·9	0·2
*SA*23	Berks	5·2	4·1	1·1
*SA*24	Berks	2·8	1·8	1·0
*D*69	Wales	67·0	64·0	3·0
*D*154	Wales	85·0	79·0	6·0

Table 4 lists the total alpha activities and the relative contents of the two natural series observed in specimens of grass ash made available to us many months after ashing. It will be seen that the total alpha activities range from 1·1 to 85·0 μμc. per gm. ash—a factor of almost 80 to 1. The higher values were found in specimens derived from Wales and Scotland, and in these cases the alpha activity is very largely due to the radium series which contributes up to 90 per cent of the total alpha activity.

It will be seen from comparison of Tables 1 and 4 that no simple relation is apparent between the natural activity of a particular specimen of grass and the activity of the soil in which it grows.

Table 5 gives the results of serial observations on six samples of grass ash at 30, 100 and 180 days subsequent to ashing. No evidence of change of thorium series activity was observed in these specimens, whereas the radium series content in each case

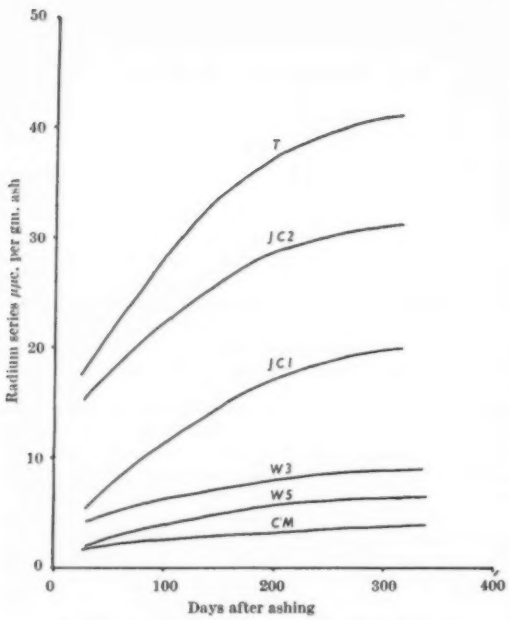

Fig. 2. Increasing activity of grass ash specimens

increased with time and is still rising some 300 days after ashing. After 30 days the radon, radium *A* and radium *C′* lost during ashing will have reached equilibrium with the radium-226 present in the ash. Assuming that the subsequent rise in activity is due to the growth of a single alpha-emitting nuclide, the half-life of this emitter has been calculated from the rate of growth of activity of each specimen (Fig. 2) and is given in the last column of Table 5.

Table 5. Grass Ash Activities in μμc./gm. Ash

Ref.	Origin	Thorium series	Radium series 30 days	100 days	180 days	Calculated half-life in days
JC1	Wales	1·2	5·6	11·4	16·2	151
JC2	Wales	2·4	15·6	22·4	27·9	152
T	Wales	3·0	18·4	28·4	36·4	145
CM	Berks	0·5	1·96	2·55	3·02	142
W5	Cumberland	4·0	2·00	3·60	5·60	143
W3	Cumberland	1·8	4·3	6·3	7·8	126

The mean half-life calculated for the six specimens is 143 days and there would seem to be little doubt that the rise of activity after 30 days is due to the build-up of polonium-210, lost in the ashing process, to equilibrium with the 22 year half-life lead-210 existing in the grass at a much higher level of activity than radium-226.

Table 6 gives the total alpha activities found in various parts of plants derived from Central Africa together with the activity of the soil in each case. It will be seen that the leaf and the bark possess the higher values of activity with the fruit usually at a much lower level. Again, there does not appear to be any correlation between the activity of different species of fruit and that of the soil in which the plant has grown.

Table 7 illustrates the increases of alpha activity observed in a few selected specimens of leaf ash, the first four samples showing typical increases due to the radium series and the remaining three due to the thorium series.

Assuming that the rise of activity of the radium series is due to the growth in activity of a single alpha emitter, the half-life of this nuclide has been calculated from the data of Table 7. The values are respectively 163, 139, 124 and 167 days with a mean half-life of 148 days. Once again there would appear to be little doubt of the phenomenon being due to the growth of polonium-210 to equilibrium with its parent lead-210.

The increases of thorium series activity appear to be linear up to the latest time of observation—300 days after ashing—indicating the growth of an alpha emitter the half-life of which is much longer than 300 days. The thorium series contains only three members with half-lives longer than 300 days, namely, the head of the series thorium-232, its daughter radium-228 (half-life 6·7 years) followed by thorium-228 (half-life 1·9 years). During the whole of our investigations on human, animal and plant tissues no evidence has yet been found, even by alpha spectroscopy, of the presence of thorium-232 in such materials.

In the absence of thorium-232 at a higher level of activity than its daughter radium-228, there remains only one possible explanation for the growth of activity due to the thorium series at the rates indicated in Table 7, that is, by the growth of thorium-228, and hence of all the subsequent short-lived members of the series, towards equilibrium with its parent radium-228.

If radium-228, not itself an alpha emitter, exists in the leaf ash at a level of activity higher than its daughter thorium-228, then the observed increases in thorium series activity are explained. This in turn implies that the plant takes up the radium isotopes in preference to thorium and is in agreement with our earlier findings for human and animal tissues and for plant foods. In all these cases the radium contents are invariably in excess of the thorium levels, in spite of the greater abundance of the latter in the soil.

One of the outstanding features of these observations is the very wide range of natural alpha activities found in vegetation compared with that in the corresponding specimens of soil. We recognize the

Table 6. T.A.A. 10^{-14} c./gm. Raw at 30 Days

Specimen	Soil	Fruit	Leaf	Twigs	Trunk	Bark	Root
Banana	2,060	0·8	83·0	—	—	—	—
Manioc 1	2,520	—	28·5	—	26·8	—	13·5
Manioc 2	2,840	—	8·4	—	—	12·4	1·8
Coconut	1,110	1·0	—	—	—	135·0	—
Paw-paw	2,880	3·5	26·7	—	12·6	—	—
Coffee	1,370	6·5	8·4	—	—	27·9	—
Rubber	1,560	2·3	9·7	17·8	—	13·4	—
Cocoa	1,980	1·8	21·2	13·9	—	28·4	—
Cotton	2,120	7·6	52·0	29·4	—	—	—
Pommes-sur-terre	1,810	1·4	12·8	—	—	—	—

Table 7. Activities in μμc./gm. Ash

Specimen	Radium series 30 days	100 days	300 days	Thorium series 0 days	100 days	300 days
Coffee leaf	1·6	3·6	6·9			
Pommes-sur-terre leaf	3·0	5·0	8·0			
Manioc leaf	3·2	5·8	9·6			
Rubber leaf	3·7	7·8	14·1			
Cotton leaf				2·6	4·4	8·4
Cocoa leaf				0·8	1·6	3·4
Paw-paw leaf				2·2	3·3	5·5

difficulty of obtaining representative samples of such materials; but it is clear that no simple general correlation exists between the plant and soil activities.

It has been interesting to observe the widespread and often predominant activity in vegetation due to polonium-210 which appears to be present in specimens ranging from British grasses to plants of various species from Central Africa. It is evident that this substance or one of its precursors such as radon-222 or lead-210 may be taken up directly from the soil. It has been shown by Jaki and Hess[7] that even moderate rainfall can restrict the rate of escape of radon-222 from the surface of the soil, and it is clear that in areas of high rainfall this factor could result in concentrations of lead-210 and in turn polonium-210 being produced in the top layer.

A linear relationship between the alpha activity of grasses and the annual rainfall has been demonstrated by our colleague, Mr. C. R. Hill[8], and suggests that polonium-210 or one of its precursors may also be taken up directly from rain. The relative importance of the contributions resulting from these two mechanisms presumably varies from site to site, depending on parameters such as species of plant, soil drainage characteristics, depth of the water table below the surface and probably many other factors.

The complexity arising from the evident preference of vegetation for radium rather than thorium isotopes together with uncertainty of the degree of radioactive equilibrium existing in the plant–matt–soil system at any particular time renders generalization dangerous.

We have so far little information concerning variation of the natural alpha activity of plant materials with season, rate of growth and many other parameters. It is clear that in order to define the alpha activity of vegetation on or near a given site, complex sampling procedures are necessary, followed by serial measurements spread over a considerable time.

We express our gratitude to the Westminster Hospital Medical School Expedition, 1958, for making available to us the range of soil and plant materials from Central Africa. We would also like to thank Dr. R. Scott Russell, director of the Radiobiological Laboratory of the Agricultural Research Council, for providing the numerous assay samples of soils, matts and grasses. Finally, we wish to thank our colleagues, Mr. C. R. Hill and Miss Mary Duggan, of this Department, for their assistance during these investigations.

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LEAD-210 AND POLONIUM-210 IN GRASS

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IN recent publications from this Department[1,2] it has been shown that the α-activity observed in certain samples of grass is largely due to the presence of polonium-210 (radium *F*), accompanied by its parent lead-210 (radium *D*). In the present communication evidence is presented that suggests that a large part of such activity may originate as a decay product of atmospheric radon (Table 1), which is afterwards deposited on to the grass by rainfall.

Table 1. THE LONG-LIVED DECAY PRODUCTS OF RADON-222

Nuclide	Half-life	Mode of decay
^{210}Pb (Ra D)	22 yr.	$\beta\gamma$
^{210}Bi (Ra E)	5 day	β
^{210}Po (Ra F)	138 day	α
^{206}Pb	stable	

Samples of grass and topsoil were collected during the first week of December 1959 from twenty well-separated points in the southern part of Great Britain, chosen to provide a wide variety of soil and rainfall conditions. Total α-activity measurements[3] were made on the dried grass and soil samples and also on a number of grass ashes. Observation of the build-up of polonium-210, following its volatilization on ashing, has confirmed that the α-activity measured in the grass samples was again due mainly to this nuclide. A similar increase in α-activity with time was observed in the case of the unashed dry grass samples, but from a relatively higher initial level, indicating that the polonium-210 in the grass at the time of collection had already reached between 35 and 80 per cent equilibrium with its parent lead-210.

In Fig. 1 the measured total specific α-activities of the individual dry grass samples (extrapolated to the condition of equilibrium between polonium-210 and lead-210 and hence an approximate measure of the respective lead-210 concentrations) are plotted against the values of mean annual rainfall at the sites of collection. A linear relation is clearly suggested, the value of the correlation coefficient being 0·87. The lead-210 concentrations have also been found to be related to the β- and γ-activities due to fission products[4] for which, as is well known, the predominant mechanism of deposition is wash-out in rainfall. No correlation was found between the total α-activity of the grass and that of the soil.

To account for these observations, two possible mechanisms might be postulated: (*a*) uptake of lead-210, or one of its short-lived precursors from the soil, and (*b*) direct deposition in rain of a partial equilibrium mixture of lead-210, bismuth-210 and polonium-210, produced by decay of atmospheric radon-222. While uptake from the soil probably occurs to some extent, the observed correlation with rainfall and with fission product activity suggests that direct deposition must be important. As shown below, such evidence is supported by the similarity between the observed levels of lead-210 activity in grass and those that might be expected on the basis

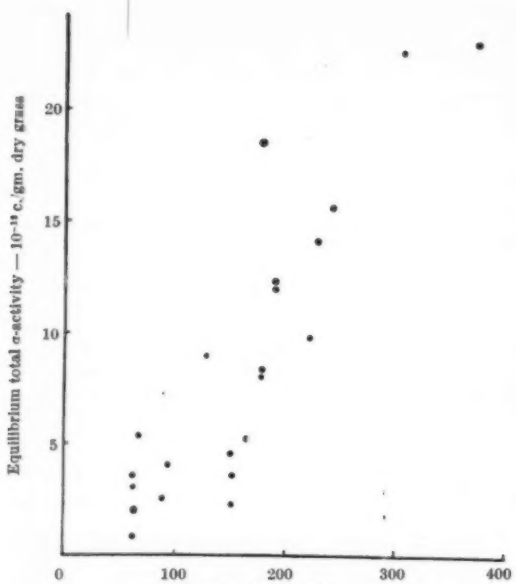

Fig. 1. Variation with rainfall of α-activity in grass

of present knowledge of the abundance and behaviour of atmospheric lead-210. In addition, we have observed: (*a*) that the activity appears to be confined mainly to parts of the plant exposed to the atmosphere, and (*b*) that the ratio of lead-210 to total lead in a sample of grass ash may be twenty times greater than the average value for lead of mineral origin.

As is well known, radon-222 is released continuously by the land surfaces of the Earth, and a reservoir of this gas is thereby maintained in the atmosphere. Radioactive decay of atmospheric radon-222 and its short-lived daughters results in the formation of lead-210, which eventually returns to the Earth's surface. Burton and Stewart[5] have recently investigated this process in some detail and have shown that the mean residence time of the total lead-210 content of the Earth's atmosphere is about four weeks, a period sufficient for appreciable atmospheric mixing to occur yet short compared to its radioactive half-life of 22 years. These workers have also shown that the mean rate of deposition of lead-210 in rain at Harwell, computed for a mean rainfall of 73 cm./year, is $1{,}650 \times 10^{-12}$ c./m.²/year, in reasonable agreement with the total rate of production of atmospheric lead-210 estimated from data on the rate of release of radon-222 from the Earth's surface and its concentration and distribution in the atmosphere.

Since appreciable atmospheric mixing is known to occur, it seems unlikely that the concentration of lead-210 in rainwater would be affected significantly by local variations in precipitation-rate, and we may therefore conclude from the above data that deposition of lead-210 at any point in Great Britain takes place at a rate of about 2.260×10^{-12} c./m.²/year for each 100 cm. of annual rainfall. In the three-month period that preceded the collection of our samples, the yields of grass at the various collection points are estimated to have been in the range 20–200 gm./m.² (dry weight), and precipitation in this period was 23 per cent of the mean annual value. On the extreme assumption of complete retention of activity by the grass following deposition in rain, values of specific activity could thus have been expected to occur in the range $2{\cdot}6–26 \times 10^{-12}$ c./gm. of dry grass for each 100 cm. of annual rainfall. It is therefore apparent that, within the rather wide limits of uncertainty inherent in the above assumptions, the levels of lead-210 observed in grass (Fig. 1) are comparable with those that might have been expected as a result of deposition from the atmosphere.

Uptake of Polonium-210 by Sheep

The recognition that polonium-210 occurs as a natural contaminant of grass has suggested the investigation of its possible uptake by herbivores. At the same time that the above grass samples were collected, samples of lamb kidney, stated to be of local origin, were purchased from several shops in each of two Welsh market towns close to areas of high rainfall. Total α-activity was measured on minced, acetone-dried tissue and, in two cases, tissue samples from the cortex and medulla were measured separately. Results of these measurements are given in Table 2.

Table 2. α-Activity measured in Dried Lamb Kidney (10^{-12} c. per gm. Wet Tissue)

Whole kidney	Cortex	Medulla
1·79	—	—
1·76	1·97	1·10
1·67	2·38	0·66
0·09	—	—
0·12	—	—
0·68	—	—

Alpha spectroscopy[1] was carried out on one sample of whole kidney and the spectrum found to consist of a single line with an energy value corresponding to that of polonium-210. Confirmation that this is the nuclide responsible, and that it occurs in the absence of lead-210, was provided by observations of the decay of total α-activity. The observed localization of activity in the cortex, which is a known characteristic of polonium[6], gives further support to this finding. It is of interest that studies on man, rabbits and rats have shown that between 5 and 15 per cent of the total body burden of polonium may be present in the kidneys[6].

Conclusion

It appears that an important contribution to the observed α-activity of grass may be provided by a process of 'natural fall-out' in which lead-210, resulting from decay of atmospheric radon, together with a fraction of the equilibrium amount of its descendant polonium-210, are deposited by rainfall directly on to foliage. Metabolic uptake of part of this activity by sheep is indicated by the presence in the kidney of polonium-210.

I wish to acknowledge the support and encouragement of Prof. W. V. Mayneord, in whose Department this work was carried out. I am also indebted to Mr. C. L. Day, of the Chester Beatty Institute, who kindly carried out an estimate of the lead content of a sample of grass ash.

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PARALLELISM OF CHANGES PRODUCED BY COOLING AND BY DRUGS KNOWN TO AFFECT ADRENERGIC MECHANISMS

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RESERPINE, guanethidine, bretylium, tyramine, amphetamine, ephedrine and dichloro*iso*prenaline are all substances known either to mimic or to modify adrenergic mechanisms, and their modes of action, still uncertain, have stimulated much work and discussion. During a comparative study of the effects of these drugs on skeletal muscle and on mechanisms mediated either through cholinergic or adrenergic components of the autonomic nervous system, it has been found that the responses obtained from animals at normal temperatures under the influence of these drugs were very similar to those obtained in untreated animals at lowered body-temperatures.

All the experiments have been carried out on cats under chloralose anæsthesia, and when effects of cooling were studied body-temperature was lowered either by the circulation of cold water through a fine rubber bag inserted into the abdominal cavity or by keeping the anæsthetized animal on an unheated operating table. Under anæsthesia, the body- and especially the muscle-temperature of cats tends to fall very rapidly[1]. Both methods produced a rather slow but steady fall in body-temperature without perceptible shivering. Two types of experiments have been performed: in the first the animal was pre-treated for one or several days with the drug under study; in the second, the drug was administered during the actual experiment. The results with tyramine, ephedrine and dichloro*iso*prenaline are from acute experiments only, those with guanethidine, bretylium and amphetamine from both acute and 'pretreated' and those with reserpine from 'pretreated' only.

It is well known that lowered body-temperatures markedly modify physiological processes and alter the effects produced by pharmacologically active substances. For example, induced hypothermia is usually accompanied by a fall in blood pressure and bradycardia. The responses of various drugs are either increased and prolonged or reduced. Throughout the present experiments the following responses have been compared in normal and pretreated animals at various body-temperatures: (1) the effects of adrenaline, noradrenaline, *iso*prenaline and acetylcholine on blood pressure; (2) the contraction of the nictitating membrane elicited by stimulation of the cut peripheral stump of the cervical sympathetic; (3) the effect of vagal stimulation on the heart; for this the left vagus nerve was divided in the neck and the peripheral end, separated from the sympathetic, was excited electrically; (4) the effect of a blocking dose of decamethonium on skeletal muscles.

Cooling

Fig. 1 shows typical results from an untreated animal at various body-temperatures. In this particular experiment the blood pressure of the animal was initially relatively low, and therefore cooling produced a marked bradycardia without further lowering of blood pressure. As cooling proceeds, the onset of the response to adrenaline, noradrenaline, *iso*prenaline and acetylcholine is slowed, the magnitude of the response increases and the duration of action is prolonged. Over the temperature-range examined (39°–26° C.) the magnitude of these responses undergoes a diaphasic change: it increases down to about 30° C., but below this temperature starts decreasing. The response to adrenaline is nearly always more affected than that to noradrenaline. On the other hand, the responses of the heart to vagal stimulation and the block produced by decamethonium increase as temperature decreases. Lowered muscle temperature is known to increase, in both animals and man, the magnitude of the effect of depolarizing drugs and markedly prolong their duration of action[2,3]. These changes appear to be independent of the actual metabolic fate of the drug; for example, decamethonium is a substance which is not destroyed in the body, whereas suxamethonium, another depolarizing drug, is rapidly hydrolysed. Cooling, however, prolongs the block produced by decamethonium, more than, or at least as much as, that produced by suxamethonium.

At lowered body-temperature various substances, but especially *iso*prenaline and adrenaline, initiate a phasic variation in the blood-pressure pattern (Fig. 1) possibly due to the initiation of phasic variations in the tone of the peripheral blood vessels.

Reserpine, Guanethidine, Amphetamine, Ephedrine, Bretylium, Tyramine and Dichloro*iso*prenaline

In animals treated either acutely or chronically with any of the above compounds, the effect of vagal stimulation on the heart, the duration of the decamethonium block, and the response of blood pressure to acetylcholine are all increased (Figs. 2–5). The magnitude of these changes is, of course, influenced by the duration of the pretreatment and the dose. The fall in blood pressure produced by *iso*prenaline is also increased in the presence of all these drugs with the exception of dichloro*iso*prenaline, a drug known to antagonize the action of *iso*prenaline[4]. An interesting point is that the effect of dichloro*iso*-prenaline on vagal stimulation, acetylcholine and the duration of the decamethonium block appears before *iso*prenaline is antagonized. A phasic variation in the blood pressure pattern appeared regularly again, either spontaneously or initiated by *iso*prenaline, adrenaline and to a lesser degree by noradrenaline. In contrast, the rise in blood pressure produced by adrenaline and noradrenaline ranged from a marked potentiation to more or less complete abolition depending on the drug administered, the dose and the duration of the pretreatment. For example, in acute experiments with tyramine, amphetamine and ephedrine at normal body-temperature, there was an initial reduction of the responses of the blood pressure to both adrenaline and noradrenaline. Throughout this work it was quite obvious that a fall in body-temperature as small as 2–3° C. appreciably affected all responses. Great care, therefore, was taken to

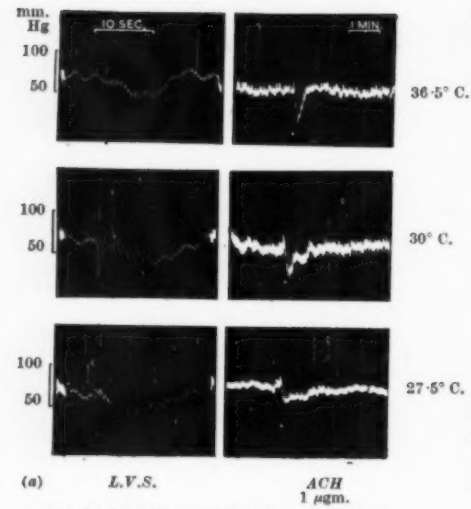
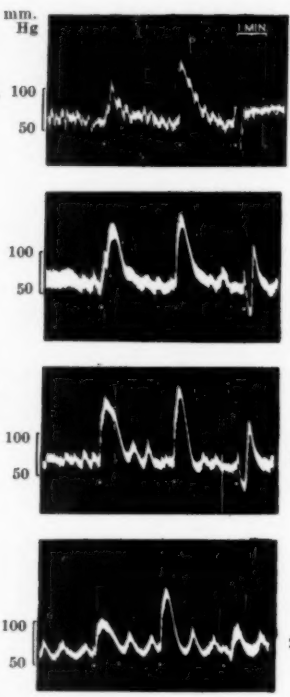
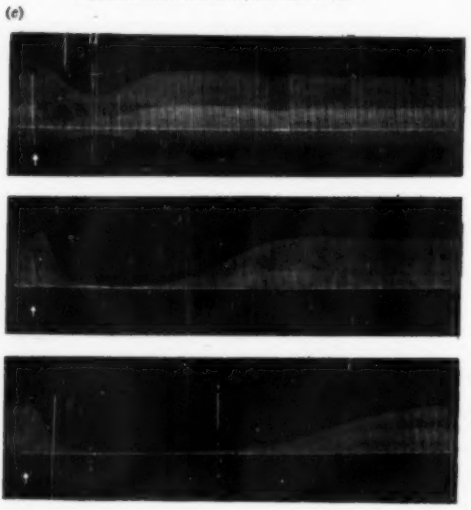


Fig. 1. Cat, 3·2 kgm. Effect of vagal stimulation (*L.V.S.*), acetylcholine (*ACH*), adrenaline (*A*), noradrenaline (*NOR*), isoprenaline (*ISO*) and decamethonium (*DEC*) at various body- and muscle-temperatures. (*a*) and (*b*), recordings of blood-pressure; (*c*), recording of muscle contractions. In this and Fig. 5 the tracings are recordings of maximal twitches from the tibialis anterior muscle in response to indirect stimulation delivered once every 10 sec. *L.V.S.* = left vagus stimulation at 10/sec. for 10 sec.





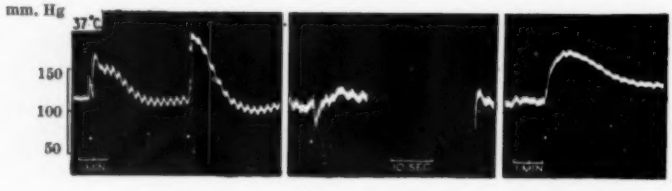


Fig. 2. Cat, 2·8 kgm. Guanethidine pretreated, 8 mgm./kgm. for two days. Blood-pressure responses to adrenaline (*A*), noradrenaline (*NOR*), acetylcholine (*ACH*), left vagus stimulation (*L.V.S.*) and amphetamine (*AMPH*)

ensure that the normal body-temperature of the cat, which ranges between 37° and 38° C., was kept constant. Independent of the change produced, however, the effect on adrenaline was nearly always more marked than that on noradrenaline.

Of the various drugs used, reserpine has produced changes most closely resembling those observed after cooling; the various responses were markedly increased and prolonged even with doses of reserpine which had no apparent effect on the function of adrenergic nerves. The doses used ranged from 5 μgm. to 1 mgm. per kgm. body-weight, and the duration of the pretreatment from one to ten days. Even with a dose as low as 5 μgm. per kgm. administered for five days, the changes produced were quite marked (Fig. 4). In animals treated with reserpine, the administration of small doses of guanethidine, amphetamine or ephedrine further potentiated the various effects.

For the remaining compounds the range of doses used is given in Table 1.

Table 1

	Pretreatment (mgm./kgm.)	Acute (mgm./kgm.)
Guanethidine	0·2–10	1–5
Bretylium	2–20	3–20
Amphetamine	2	0·1–2
Ephedrine		0·3–2
Tyramine		0·1–1
Dichloroisoprenaline		1–4

In the animals pretreated with guanethidine or with bretylium, the potentiating effects appeared long before the blockade of adrenergic neurones. On the other hand, amphetamine and ephedrine were still producing their usual rise in blood pressure in the presence of large doses of guanethidine and bretylium and long after the adrenergic neurones had been blocked (Fig. 2).

Discussion

A lowering of body-temperature slows the rate of all physiological processes, but some are more affected than others. For example, for a given fall in temperature the decrease in rate of metabolic and rhythmic processes is two to three times as great as

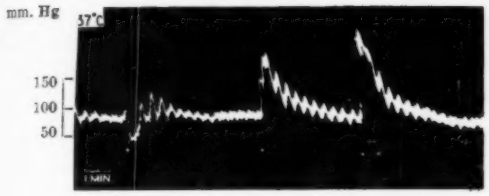


Fig. 3. Cat, 4·6 kgm. Reserpine pretreated, 50 μgm./kgm. for three days. Blood-pressure responses to adrenaline (*A*), noradrenaline (*NOR*) and *iso*prenaline (*ISO*)

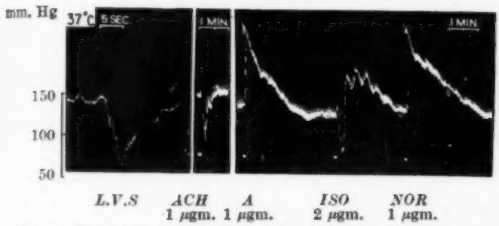


Fig. 4. Cat, 2·9 kgm. Reserpine pretreated, 5 μgm./kgm. for five days. Blood-pressure responses to left vagus stimulation (*L.V.S.*), acetylcholine (*ACH*), adrenaline (*A*), *iso*prenaline (*ISO*) and noradrenaline (*NOR*)

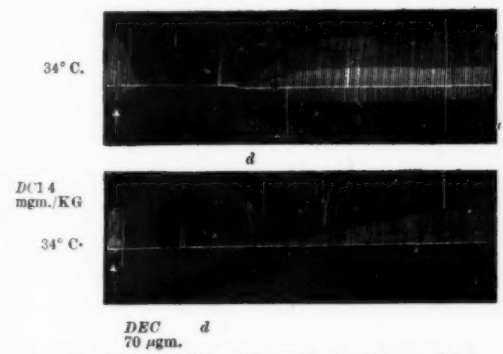


Fig. 5. Cat, 2·8 kgm. Effect of decamethonium before and 1 hr. after the intravenous administration of 4 mgm./kgm. dichloro-*iso*prenaline; *d* = direct stimulation

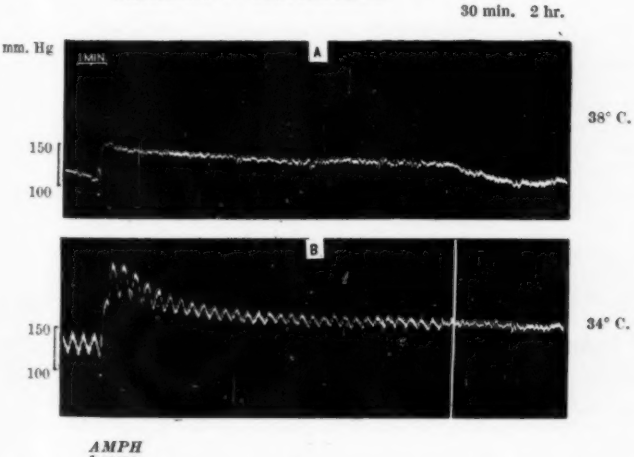


Fig. 6. Effect of 0·3 mgm./kgm. of amphetamine sulphate on the blood pressure of a cat (*A*) at 38° C. and (*B*) another cat at 34° C.

the decrease in rate of diffusion of metabolites[5]. The same is apparently true for the action of various drugs. Some drugs become more effective at lower temperatures, whereas the action of others is reduced. On this basis, Johnson, Eyring and Polissar[6] have classified drugs into two types. Among the first type are those drugs which produce their action by competitively inhibiting enzyme systems. The second type includes a large number of narcotics. There are also drugs exhibiting both types of effect. According to this classification, the drugs used in the present work must belong to the first type, since all become more effective at lower temperatures. Fig. 6 illustrates this point. In two different animals, one at 38° C. and the other at 34° C., the same dose/kgm. of amphetamine was administered. The action produced by the drug was both more pronounced and more prolonged in the cooled animal.

The striking resemblance between the changes produced by cooling alone and those produced by the drugs under consideration, together with the fact that the effects of these drugs are increased at lower temperatures, suggested the possibility of a common basis for their mechanism of action. By far the most obvious change produced either by cooling or by any of the drugs studied is a prolongation of responses elicited by various means; obviously the rate of recovery of the effector cells after activation is slowed. This appears to be independent of either the type of activation (stimulation or inhibition) or the type of nervous control (adrenergic or cholinergic; autonomic or motor). It is therefore very tempting to suggest that the action of these drugs, so far as this phenomenon of prolongation is concerned, is brought about by inhibition of the metabolic processes underlying 'recovery' of a cell after activation.

There is greater uniformity in the changes produced at cholinergic than at adrenergic sites. At cholinergic sites each of the drugs in this group gave rise to the same type of change though to varying extent, whether administered chronically or acutely. On the other hand, at the adrenergic sites there were distinct differences, possibly because by virtue of their chemical structure these substances are presented here with a greater variety of enzymic processes to act upon—processes concerned with the synthesis, storage, release and destruction of the catecholamines all along the adrenergic pathway. The resultant effects, therefore, will depend (*a*) on the direct 'mimicking' ability of the compound (as in the case of tyramine, amphetamine, ephedrine), (*b*) on the ease with which they penetrate cell membranes, and finally (*c*) on their action as inhibitors of various enzymic processes. The wide spectrum of effects which these drugs produce on adrenergic systems could thus be explained.

But what can be the general mechanism by which these drugs interfere with the recovery of a cell after excitation, an effect seen at both cholinergic and adrenergic sites? Possibly by competitively inhibiting enzyme systems concerned with the restoration of a cell after activation. These various molecules look chemically very different, but we cannot really see how they come to be competitive. But take the following

points into consideration: (*a*) while noradrenaline is liberated close to the effector cells, adrenaline is released mainly from the adrenal medulla into the blood stream, which brings it into contact with every single cell in the body; (*b*) only adrenaline gives rise to marked metabolic changes; and (*c*) both cooling and the drugs used throughout this work influence the responses to adrenaline a great deal more than those to noradrenaline. These facts put together make it very tempting to speculate that adrenaline itself may be directly concerned in the 'recovery' process of a cell after activation. Then the changes produced by reserpine, guanethidine, bretylium, tyramine, amphetamine, ephedrine and dichloro*iso*prenaline on the 'recovery' mechanism could be explained as due to a 'displacement' of adrenaline from its points of attachment.

My thanks are due to Burroughs, Wellcome and Co., Ltd., for the supply of bretylium; to Ciba Laboratories, Ltd., for guanethidine; and to Eli Lilly and Co., for the dichloro*iso*prenaline. This investigation was supported by a grant from the Palissade Foundation, Inc., of New York.

Summary

It has been found that reserpine, guanethidine, bretylium, tyramine, amphetamine, ephedrine and dichloro*iso*prenaline produce changes closely analogous to those observed in animals the body temperature of which has been lowered. The metabolic basis of these changes is discussed.

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CARBON-14 LABELLED HYBRIDS OF HÆMOGLOBIN

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Preparation of ^{14}C-L-Leucine labelled Hybrids of Adult and Sickle-Cell Hæmoglobins

HUMAN adult hæmoglobin (HbA) and its allelic mutant sickle-cell hæmoglobin (HbS) each consist of two pairs of polypeptide chains, α and β, of known *N*-terminal sequences[1]. Sickle-cell hæmoglobin differs from adult hæmoglobin in the substitution of a valyl residue for a glutamyl residue[2] in the β chains[3]. Both hæmoglobins dissociate into two molecules of approximately equal molecular weight in acid and in alkaline solutions; the products recombine to form whole molecules in neutral solution[4–6]. Singer and Itano have reported that mixtures of sickle-cell hæmoglobin and adult hæmoglobin, dissociated together at *p*H 4·7, recombine upon neutralization with an exchange of half-molecular sub-units[7].

In studies of sub-unit recombinations of various hæmoglobins we have developed a general method for the preparation and isolation of useful amounts of highly radioactive hæmoglobin hybrids in which one type of sub-unit is radioactive while the other is inactive. Such selectively labelled *hybrid* hæmoglobins are of use in the determination of the chemical nature of sub-units of genetically variant hæmoglobins.

The preparation of carbon-14 labelled hybrid hæmoglobin molecules is illustrated here with the adult, sickle-cell hæmoglobin system. The carbon-14 hybrid hæmoglobins have been formed upon recombination after dissociation of mixtures of the two hæmoglobins in either acid or alkaline solutions.

Formation and Isolation of Carbon-14 Hybrids of Adult and Sickle-Cell Hæmoglobin

Equimolar mixtures of human adult normal and sickle-cell carbonmonoxyhæmoglobin, one uniformly labelled with carbon-14 L-leucine, were dialysed for 24 hr. at 3° C. against either a phosphate buffer (0·033 *M* disodium hydrogen phosphate, 0·0167 *M* sodium phosphate, 0·15 *M* sodium chloride) of *p*H 11·0 or an acetate buffer (0·1 *M* sodium acetate, 0·15 *M* sodium chloride, 0·042 *M* acetic acid) of *p*H 5·0. This dialysis was followed by a dialysis to a *p*H of 7·22 against the buffer specified as chromatographic developer No. 1 by Allen, Schroeder and Balog[8]. 20–50 mgm. of the mixtures were separated on an '*IRC*-50' column in equilibrium with developer No. 1 at 6° C. The adult hæmoglobin was eluted at this temperature, after which the sickle-cell hæmoglobin was eluted at 28° C. The concentrations of the chromatographic fractions were determined spectrophotometrically at the absorption maxima of carbonmonoxyhæmoglobin at 541 or 415 mμ; or, in cases where the hæmoglobins were believed to be contaminated with methæmoglobin cyanide, at the isobestic wave-length 522 mμ.

The specific activities of the hæmoglobin samples were measured using a Nuclear-Chicago gas-flow Geiger counter, model *D*-47, equipped with a 'micromil' window. At the high level of specific activities of these hæmoglobins, less than 0·5 mgm. was required per planchette. No corrections for self-absorption were necessary with these amounts of hæmoglobin. A fixed volume of solution, 0·5 or 1·0 ml., was plated.

In experiments with radioactive human sickle-cell hæmoglobin it was necessary to free the material of the fast-moving minor hæmoglobin components in sickle-cell hæmoglobin. This was accomplished by chromatography of 50–100 mgm. of sickle-cell hæmoglobin with developer No. 2 (ref. 8). The major sickle-cell hæmoglobin component was recovered by warming the column to 28° C. The hæmoglobin solutions were concentrated by centrifuging for 18 hr. at 40,000 r.p.m. in the No. 40 rotor of a 'Spinco' preparative ultracentrifuge at 5° C. Concentrated solutions, usually containing 8–15 per cent hæmoglobin, were withdrawn from the bottom of the centrifuge tubes with a hypodermic syringe fitted with a 4-in. 22-gauge needle.

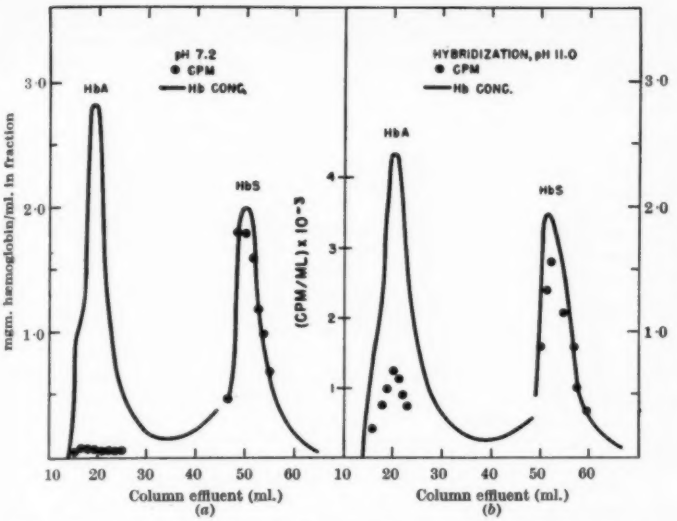

Fig. 1. Transfer of radioactive α sub-units in a mixture of human adult hæmoglobin and carbon-14-L-leucine labelled sickle-cell hæmoglobin dialysed to *p*H 11 and afterwards dialysed to *p*H 7·2. (*a*) Experiment 6, (*b*) experiment 4, Table 1.

Preparation of Radioactive Hæmoglobins

The unlabelled hæmoglobins were prepared from freshly drawn blood samples from either normal or sickle-cell anæmic individuals by the procedure of Drabkin[9]. The hæmoglobin was not crystallized[8].

It was desired that the radioactive hæmoglobins used in the hybridization experiments be uniformly labelled in the α and the β chains. L-leucine was chosen because of the abundance of this amino-acid in the molecule and the presence of leucine in both α and β *N*-terminal peptides. It has recently been shown that there are close to an equal number of leucine residues in both chains[10]. Uniform labelling, therefore, should lead to equal specific activities in the α and β chains.

The radioactive hæmoglobins were prepared from the red blood cells of anæmic donors. Blood samples containing 15–40 per cent reticulocytes were used within 2 hr. after the blood was drawn. Following four washings with cold isotonic saline solution, the red cell suspensions were incubated by a modification of the procedure devised for rabbit reticulocytes by Borsook *et al.*[11].

The complete incubation mixture was prepared using the following stock solutions :

(*a*) 0·13 *M* sodium chloride, 0·005 *M* potassium chloride, 0·0075 *M* magnesium chloride, in redistilled water.
(*b*) 0·22 *M* glucose in solution (*a*), prepared fresh for each incubation.
(*c*) 0·01 *M* ferrous ammonium sulphate in solution (*a*), prepared fresh.
(*d*) 0·27 *M* sodium bicarbonate in redistilled water, prepared fresh.
(*e*) 0·01 *M* glutamine in solution (*a*), stored frozen.
(*f*) Amino-acid mixture : *l*-alanine 180, *l*-arginine 100, *l*-aspartic acid 380, *l*-cysteine 50, glycine 400, *l*-histidine hydrochloride 500, *l*-isoleucine 52 (*l*-leucine 52), *l*-lysine hydrochloride 330, *l*-methionine 50, *l*-phenyl alanine 260, *l*-proline 160, *l*-serine 175, *l*-threonine 200, *l*-tryptophan 60, *l*-tyrosine 150, *l*-valine 370, *l*-hydroxyproline 150 (amounts of amino-acids expressed as mgm. per 1,000 ml. of solution *a*). After boiling to dissolve all amino-acids, the *p*H was adjusted to 7·0 with 5 *N* sodium hydroxide. This stock solution was stored frozen in small lots which were thawed out as needed.

The following amounts of the above solutions were added, in the order given, to 10 ml. of packed red blood cells : 5·85 ml. of amino-acid mixture, 0·60 ml. glucose solution, 1·2 ml. glutamine solution, 1·8 ml. of sodium bicarbonate solution, 11·7 ml. ferrous ammonium sulphate solution. Seven micromoles, 50 μc., of Nuclear-Chicago uniformly labelled radioactive L-leucine, dissolved in 0·5 ml. solution *a*, was then added to the mixture. In these incubations the cold L-leucine was omitted.

The cells were incubated for 4 hr., washed four times and lysed with distilled water and toluene. After removal of cell debris by low- and high-speed centrifugation, the resulting hæmoglobin solutions were dialysed against several changes of distilled water to remove unincorporated carbon-14 labelled L-leucine. The specific activities of the hæmoglobins in several preparations were between 3,000 and 7,000 c.p.m./mgm.

Results of Hybridization Experiments

The results of a typical hybridization experiment and the chromatographic separation of the two hæmoglobins are shown in Fig. 1*b*. In Fig. 1*a* the results of a chromatographic separation of the same materials mixed at *p*H 7, but not dissociated at *p*H 11, show that there is little contamination of human adult normal hæmoglobin by the radioactive sickle-cell hæmoglobin. Inspection of the curves in Fig. 1 shows that no new chromatographic species have appeared as a result of the dissociation of the mixture at *p*H 11 and that transfer of activity from the sickle-cell hæmoglobin to the adult hæmoglobin occurs. The specific activity of the adult hæmoglobin after dissociation and recombination is approximately one-third that remaining in the sickle hæmoglobin. In Table 1, experiments 1–9 summarize the results of several similar experiments in which the hæmoglobins were dissociated in acid and alkaline solutions. The specific activities given in Table 1, together with standard deviations, are average values of the specific activities of all chromatographic fractions containing more than 0·2 mgm./ml. of hæmoglobin. This usually accounted for more than 80 per cent of the recovered

Table 1

Exp. No.	*p*H	Specific activities of reactants		Specific activities of products		Percentage hybridization*
		HbA	HbS	HbA	HbS	
1	11·0	3,500	0	2,600±200	860±50	99±10
2†	11·0	3,500	0	2,700	800	89
3	7·2	3,500	0	3,200±300	64±15	6±2
4	11·0	0	1,900	480±30	1,400±200	103±16
5	11·0	0	1,900	370±50	1,570±100	71±10
6	7·2	0	1,900	90±40	1,650±200	16±8
7	5·0	700	0	500±60	130±20	80±16
8	5·0	3,000	0	2,600±150	270±20	31±3
9	7·2	600	0	550±50	12±4	9±0
10	11·0	6,500	0	5,800±500	220±100	11±6
11	11·0	0	1,900	160±70	1,750±160	27±12

* The percentage of hybridization was calculated assuming a ratio of specific activities of the products of three to one for 100 per cent hybridization.

† The specific activities in this experiment were determined on single aliquots from the fractions of adult and sickle-cell hæmoglobin of highest concentration.

sample. It is seen that in all hybridization experiments at *p*H 11 the average specific activity found in the initially inactive hæmoglobin is roughly one-third of that remaining in the other hæmoglobin.

Singer and Itano have pointed out that the transfer of one-quarter of the total activity into the initially inactive hæmoglobin is presumptive evidence of the identity of one-half of the sickle-cell and adult hæmoglobin molecules. These investigators have shown the formation of electrophoretically distinguishable hybrids from sickle-cell ferrihæmoglobin and adult carbonmonoxyhæmoglobin, and have concluded that the hæmoglobin molecule dissociates into non-identical halves in acid solution :

$$(a)\ \alpha_2\beta_2 \rightleftarrows \alpha_2 + \beta_2$$

Both sickle-cell and adult hæmoglobin are known to be in the form of half molecules at *p*H 11 (ref. 5). We have found that only slight hybridization occurs when equal amounts of sickle-cell and adult hæmoglobins are brought separately by dialysis for 24 hr. to *p*H 11, mixed and held at *p*H 11 for 10 sec., and then quickly neutralized with 2·8 *M* phosphate buffer, *p*H 6·8. The results of these experiments are shown in Table 1, experiments 10 and 11. It appears from these results that the hæmoglobins under alkaline conditions may dissociate into identical halves and further dissociate into quarters :

$$(b)\ \alpha_2\beta_2 \rightleftarrows 2\alpha\beta \rightleftarrows 2\alpha + 2\beta$$

The fraction of material in the quarter molecule state must be less than 10 per cent in accordance with the results of ultracentrifuge studies in which normal cell hæmoglobin and sickle-cell hæmoglobin were shown to be half molecular at *p*H 11. On recombination by neutralization, both mechanisms lead to the same ratio of specific activities in the products. (A balanced equation for mechanism (*a*), assuming transfer of α chains only, is :

$$2\alpha_2^{**}\beta_2^{**} \rightarrow 2\alpha_2^{**} + 2\beta_2^{**} \quad \{\alpha_2^{**}\beta_2^{**} + \alpha_2\beta_2^{**}\}$$
$$\rightarrow$$
$$2\alpha_2\beta_2' \rightarrow 2\alpha_2 + 2\beta_2' \quad \{\alpha_2\beta_2' + \alpha_2^{**}\beta_2'\}$$

For mechanism (*b*) the equation is :

$$4\alpha_2^{**}\beta_2^{**} \rightarrow 4\alpha^{**}\beta^{**} \quad 4\alpha^{**} + 4\beta^{**} \quad \{\alpha_2^{**}\beta^{**} + 2\alpha\alpha^{**}\beta_2^{**} + \alpha_2\beta_2^{**}\}$$
$$\rightleftarrows \qquad \rightarrow$$
$$4\alpha_2\beta_2' \rightarrow 4\alpha\beta' \quad 4\alpha + 4\beta' \quad \{\alpha_2^{**}\beta_2' + 2\alpha\alpha^{**}\beta_2' + \alpha_2\beta_2'\}$$

By both mechanisms the apportionment of radioactivities in the products is seen to be such that the ratio of specific activities is three to one.) This proposed mechanism for sub-unit transfer implies that β and β^{s} do not combine, and similarly, $\alpha\beta$ does not combine with $\alpha\beta^{s}$.

Significance of Hæmoglobin Hybrid Formation

The hybrids labelled with carbon-14 described here are useful materials in two general areas of hæmoglobin studies. First, any peptide fragment isolated from digests of the whole molecule may be identified with respect to the sub-unit of origin. An example of this was the first identification of the aberrant or non-transferring sub-unit in the normal hæmoglobin/sickle-cell hæmoglobin system with the β *N*-terminal peptide[3]. In the second kind of study, a sub-unit transferring between two hæmoglobins may be readily followed as in the case of reactions between hæmoglobins A and F (ref. 12), S and H (ref. 13), and more recently in interspecies systems between adult hæmoglobin and rabbit hæmoglobin. In the latter case, through the use of $\alpha_2^{*}\beta_2$, the compositions of the two interspecies hybrids were readily recognized (unpublished work from this Laboratory).

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EFFECTS OF *p*H AND THE NATURE OF THE PRIMARY SPECIES IN THE RADIOLYSIS OF AQUEOUS SOLUTIONS

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IT has been known for a long time that the yields observed in the action of ionizing radiations on aqueous solutions are markedly influenced by changes in *p*H (ref. 1). In several of the systems examined, for example deaerated aqueous solutions of formic acid or of methanol, it was observed that the yields of hydrogen and of the oxidation products from the solute dropped sharply on going from acid to neutral conditions. Somewhat similar *p*H effects have since been noted in various other aqueous systems[2]. As yet, however, no satisfactory explanation has been offered for these results.

In the course of an investigation of the effect of cobalt-60 γ-rays on aqueous solutions of various simple

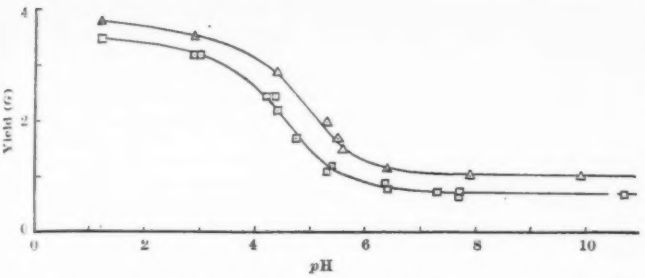

Fig. 1. Dependence on *p*H of the yields of acetone and hydrogen from aqueous solutions of *iso*propanol (10^{-2} *M*) irradiated with cobalt-60 γ-rays *in vacuo*. □, acetone; △, hydrogen

aliphatic alcohols, carried out in this laboratory, particular attention has been directed to the study of *p*H effects *in vacuo*.

In this communication we present some results obtained from *iso*propanol solutions. The main product was found to be acetone. The yields of acetone and of hydrogen from *iso*propanol solutions (10^{-2} *M*) were studied as a function of *p*H over the range *p*H ~ 1 to ~ 10. In the more strongly acid solutions (*p*H < 3) and in solutions at *p*H > 7, the yields were linear with dose, up to the highest doses used (4×10^{18} eV./ml.). In the range *p*H ~ 3 to ~ 6, however, the yield–dose plots were non-linear, falling off with increasing dose. Detailed examination down to the lowest practical doses showed that initially there was a high yield, but this could not be accurately determined. Above about 3×10^{17} eV./ml., the deviation of the plots from non-linearity was not quite so pronounced. *G*-values (molecules/100 eV.) for the yields of hydrogen and acetone in this particular *p*H range were, therefore, computed from results obtained using doses ranging from 3×10^{17} to $1{\cdot}2 \times 10^{18}$ eV./ml. Fig. 1 shows the *p*H-dependence of the radiation-yields obtained in this manner.

It was apparent from these results that some back reactions were taking place in solutions irradiated at *p*H > 3. Experiments were therefore carried out in which acetone was added to *iso*propanol solutions (10^{-2} *M*) prior to irradiation. Some results are shown in Table 1. In the *p*H range 3–6, such additions lead to notable decreases in the yields of hydrogen. It would appear, therefore, that the *p*H-dependence in *iso*propanol solutions is largely associated with back reactions involving the acetone produced by radiation. Essentially similar results have been observed with solutions of methanol (Lyons, Scholes and Smith, unpublished results) and of ethanol (Nixon and Scholes, unpublished results), where it has been found that the corresponding aldehydes enter into the back reactions.

Table 1. Effect of Acetone on the Yields of Hydrogen from *Iso*propanol Solutions Irradiated with Cobalt-60 γ-rays *in vacuo*

Solution	Yield of hydrogen (*G*)*				
	*p*H = 1·20	*p*H = 3·45	*p*H = 4·20	*p*H = 4·50	*p*H = 7·90
*Iso*propanol (10^{-2} *M*)	3·80	3·37	3·00	2·75	1·05
*Iso*propanol (10^{-2} *M*)–acetone (2×10^{-4} *M*)	3·80	3·10†	2·00	1·70	1·05

* Values for *iso*propanol solutions are taken from Fig. 1. The yields in *iso*propanol–acetone solutions are initial yields.
† 10^{-2} *M* *iso*propanol–10^{-4} *M* acetone.

Chemical reactions induced by ionizing radiations in dilute aqueous systems are due to the free radicals, denoted as H and OH, produced by the action of the radiation on the water[3]. In addition, there is some primary formation of 'molecular' hydrogen and hydrogen peroxide[4]. The overall radiolysis of water is conventionally represented as:

$$H_2O \longrightarrow H,\ OH,\ H_2,\ H_2O_2 \qquad (1)$$

Radical formation is the result of the excitation and ionization processes which occur as a consequence of the absorption of the ionizing radiations[5]. There is some controversy, however, about the fate of the electrons formed from the ionization process. Lea and Gray[5], Weiss[6] and Platzmann[7] have considered that the ejected electron is captured by a water molecule at some distance from the parent positive ion and exists, possibly attached to a water molecule, until interaction with the aqueous medium allows formation of a hydrogen atom according to the process:

$$H_2O^- \rightarrow H + OH^- \qquad (2)$$

Weiss[8] has discussed questions regarding the stability of the positive and negative ions from water, pointing out that they may have a life-time long enough to enable them to undergo chemical reactions with the solute present. Deaerated solutions of monochloroacetic acid were found to be systems in which the results could best be explained in terms of reactions of the negative ion, H_2O^- (the electron in water or 'polaron')[9].

The results reported above can only be explained if we assume the presence in irradiated neutral and alkaline solutions of *iso*propanol of two forms of the 'hydrogen atom' (cf. ref. 10). One of these dehydrogenates *iso*propanol, but the other cannot and reacts with acetone and probably also to some extent with the hydrogen peroxide produced according to reaction (1). Since it seems highly unlikely that H_2^+ and H could be the two forms under these conditions of *p*H, we must conclude that the species are H and the electron (polaron). Furthermore, they are both produced in the act of radiolysis, and the results indicate that, under these conditions, $G_H = 0{\cdot}6$ and $G_{H_2O^-} = 2{\cdot}3$. These hydrogen atoms could very well arise from excitation processes of the type[6]:

$$H_2O^* \rightarrow H + OH \qquad (3)$$

The effects of *p*H which, as described above, are essentially due to a back reaction involving acetone could then be ascribed to the competition:

$$H_2O^- + H_3O^+ \rightarrow 2H_2O + H \qquad (4)$$

$$H_2O^- + CH_3.CO.CH_3 \rightarrow H_2O + [CH_2.CO.CH_3]^- \qquad (5)$$

In the *p*H range 3–6, addition of acetone depresses the yield of hydrogen by influencing the competition in favour of reaction (5), and for the same reason one would expect non-linearity of the yield–dose plots. From the experiments in the presence of acetone the ratio of the rate constants of reactions (4) and (5) can be calculated as $k_4/k_5 = 2{\cdot}3$. It should be pointed out that H_2^+, which is formed in acid solutions[11], could still be a reacting species at low *p*H.

The above mechanism would account for *p*H effects which have been observed in many other aqueous systems. It has been reported[12] that in deaerated ethanol solutions irradiated with X-rays, G (aldehyde) drops markedly above *p*H ~ 3, but that G (glycol) is relatively unchanged; more recently, it has been shown that ethylene glycol is, in fact, formed on irradiation of oxygen-free solutions of acetaldehyde (Nixon and Scholes, unpublished results). In the case of ethanol solutions, therefore, the back reaction is:

$$H_3O^- + CH_3CHO \rightarrow H_2O + CH_3CHO^- \qquad (6)$$

leading to the conversion of aldehyde to glycol.

Hydrogen peroxide produced in reaction (1) will also compete with the proton for the polaron, according to the reaction:

$$H_3O^- + H_2O_2 \rightarrow H_2O + OH + OH^- \qquad (7)$$

When the total available number of polarons cannot be scavenged by the radiation products they may, under certain conditions, react with carbon dioxide, which is often present in evacuated systems unless special precautions are taken. The reaction with carbon dioxide can be represented by the equation:

$$CO_2 + H_2O^- \rightarrow CO_2^- + H_2O \qquad (8)$$

In formic acid solutions at low *p*H, the only radiation product of the solute is, in fact, carbon dioxide; the dependence on *p*H of the yields of carbon dioxide and of hydrogen could thus be connected with reaction (8) (possibly together with reaction (7)), competing with reaction (4). The presence of oxalic acid in neutral solutions of formic acid which have been irradiated with γ-rays has been established (Simic, Scholes and Weiss, unpublished results) and is probably formed by dimerization of the CO_2^- (CO_2H) radicals produced according to reaction (8).

Fricke and Hart[1] observed that the radiation yields of hydrogen from solutions of acetone and propionaldehyde at *p*H 3 varied with concentration, first increasing and then decreasing as the solute concentration is increased. A maximum hydrogen yield has also been observed in the irradiation of monochloroacetic acid solutions at *p*H 1·20 (ref. 9). We have confirmed that there is a maximum in acetone solutions; at *p*H 1·2 this occurs at a concentration of 10^{-2} molar. These are examples where the solute itself can react both with the hydrogen atom (or H_2^+ in acid solution) and with the polaron. At low concentrations of solute in acid media, reaction (4) is predominant and dehydrogenation processes occur. As the concentration is increased, however, increased scavenging is offset by reactions of the polaron with the solute, for example, reactions (5) and (7). Hence, the hydrogen yield goes through a maximum.

In a study of the exchange reactions induced by radiation in D_2–H_2O, Gordon and Hart[13] observed that above *p*H ~ 7 the yields of HD fell off very rapidly, and this was attributed to ionization of the OH radical. However, these particular results could be accounted for by the decrease in the extent of reaction (4) in this *p*H region. Above *p*H ~ 8 these authors noted a significant increase in the yields of hydrogen gas, an observation which would suggest that the life-time of the polaron can be sufficiently long to allow recombination to form molecular hydrogen. Such considerations, together with the large ratio of (G_{H_2O}) (G_H), would tend to support the suggestion[9] that the polarons contribute towards the molecular hydrogen yield.

We thank Prof. J. Weiss for valuable discussions and for his encouragement of this work.

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MAGNETIZATION OF SEDIMENT CORES FROM THE EASTERN ATLANTIC OCEAN

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THE remanent magnetization of sediments from the continents has been studied extensively; but only a few studies have been made on sediments from the oceans[1,2]. This article describes the results of experiments which have been made on two of a number of cores from the eastern Atlantic Ocean. The investigations will be described in detail elsewhere. They were undertaken to find out how oceanic sediments acquire their magnetic properties and how these are related to the other physical properties; thereby information on the history of the Earth's magnetic field or conversely a method of correlating oceanic cores might be obtained. Further, the study of the magnetic minerals might be of intrinsic interest.

A number of cores were collected during the cruise of R.R.S. *Discovery II* from May until July 1958[3]. The first core described, 3738, was taken on the lower slopes of a group of abyssal hills on the western edge of the Iberian abyssal plain[4] (Station 3738, 41° 00′ N., 15° 08′ W., corrected depth 5,267 m.). The second core, 3780, was taken at the bottom of a bank about 3 m. above the abyssal plain (Station 3780, 41° 26′ N., 14° 43′ W., corrected depth 5,333 m.). They were obtained with a piston corer, and were not oriented with respect to the direction of the Earth's present magnetic field. The core 3738 is about 4 m. long; results on only the top 3 m. are presented here. Core 3780 is 6 m. long.

Core 3738 consists of brown clay and foraminiferal ooze, and of mixtures of these two types of sediment; evidence of burrowing occurs at intervals throughout the length of the core. A summary of the lithology

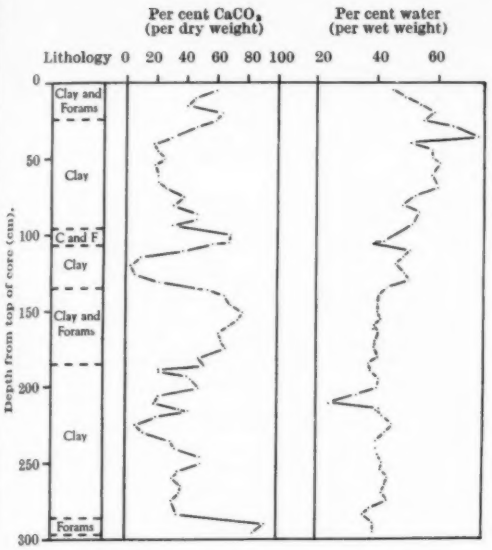

Fig. 1. Core 3738: lithology, percentage CO_3^{--} (calculated as calcium carbonate) and percentage water plotted against depth of the core

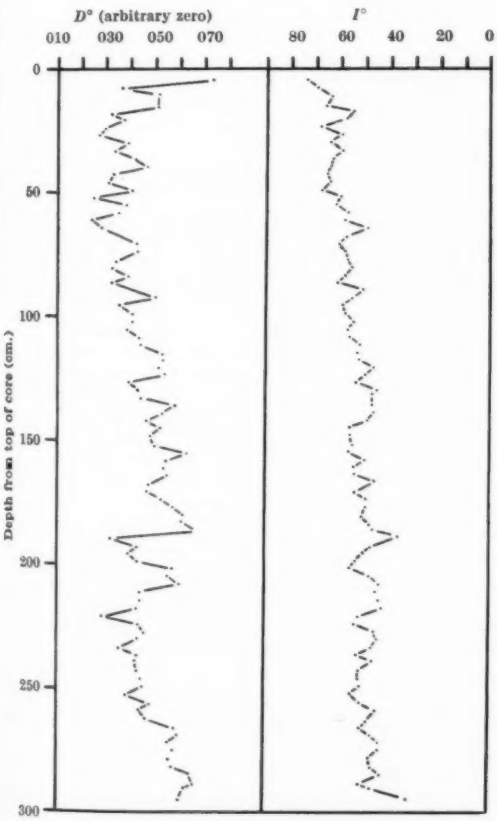

Fig. 2. Core 3738: values of $D°$ and $I°$ plotted against depth of core

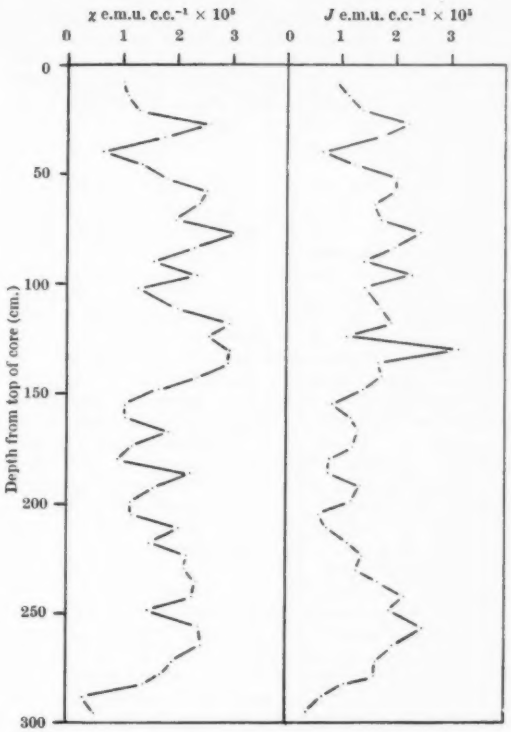

Fig. 3. Core 3738: values of χ and J plotted against depth of core

is given in Fig. 1, with the percentage of total carbonates and the water content. The carbonate content is given as a percentage of the dry weight and the water content as a percentage of the wet weight. The samples taken for the investigation of the remanent magnetization were in the form of cylinders 2·7 cm. in length and in diameter, and were taken immediately after the core had been opened and before it had dried out significantly; sampling was continuous down the core. All the samples were oriented in the same way relative to the core as a whole; the direction of the length of the core can be expected to be the vertical. The direction and intensity of the remanent magnetization of each sample was measured on an astatic magnetometer similar to that described by Collinson *et al.*[5]. The susceptibility was measured with an a.c. bridge by comparing the samples with standards.

The magnetic data are shown in Figs. 2, 3 and 4. Fig. 2 shows the variation in the values of declination, D (azimuth), and the inclination, I (dip), down the core. The values of D are plotted with an arbitrary zero and the values of I with the direction of increased depth down the length of the core as 90°. The present value of I in the area from which the core was taken is about 58° (ref. 6). Fig. 3 shows the variation in intensity of remanent magnetization, J, and the variation in magnetic susceptibility, χ, down the core; the values are given in e.m.u. c.c.$^{-1}$ of wet sediment. Fig. 4 shows histograms of the values of D and I of all the specimens measured.

The minerals which cause the magnetization have been investigated only by thermo-magnetic analysis and two sets of experiments were carried out. In

one set the change in susceptibility with temperature of the whole sample was measured using the susceptibility bridge, and in the second set magnetic separations were analysed on a thermo-magnetic balance similar in principle to that described by Chevallier[7]. The results suggest that at least 90 per cent of the magnetic moment is caused by magnetite.

The work which has been done so far could not have reproduced the known secular variation since the samples embrace an excessive time-interval. The histogram of the values of D (Fig. 4) show, however, variation over a range which is about the same as that of the known field in London. The histogram of the values of I show a greater range than that known historically and is skewed towards low values. This may be explained by the correspondence which has been found between the water content down a core and the values of the inclination, which suggests that there may be a change in the inclination by amounts up to about 20° through compaction (Figs. 1 and 2). Evidence of disturbance by burrowing animals is common, and these will rework the uppermost part of the sediment; it seems possible that the final direction of remanent magnetization has not been acquired until some time after the sediment has been deposited and that this direction has been altered further by compaction. No reversals in the remanent direction have been found in these cores, and no cross-correlation between cores taken within a mile or two of one another is at present conspicuous.

Core 3780 consists largely of material deposited by turbidity currents, and sediment of the order of 100 cm. thick may be laid down at any one time. In this core the changes in D and I are much greater than

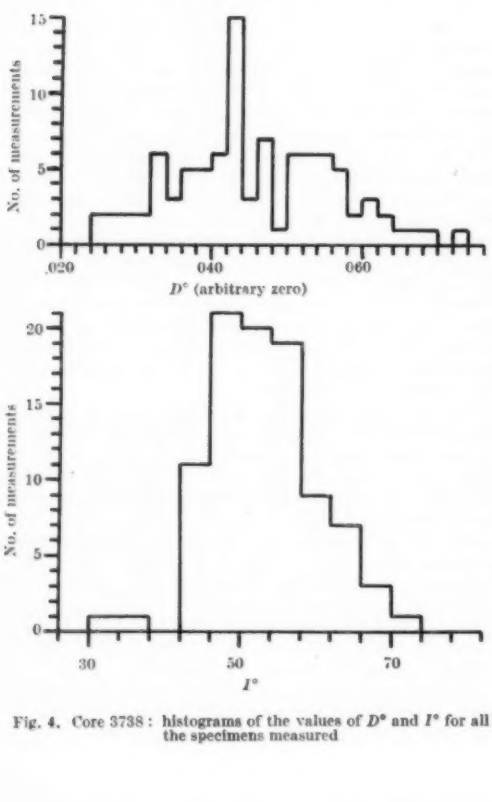

Fig. 4. Core 3738: histograms of the values of $D°$ and $I°$ for all the specimens measured

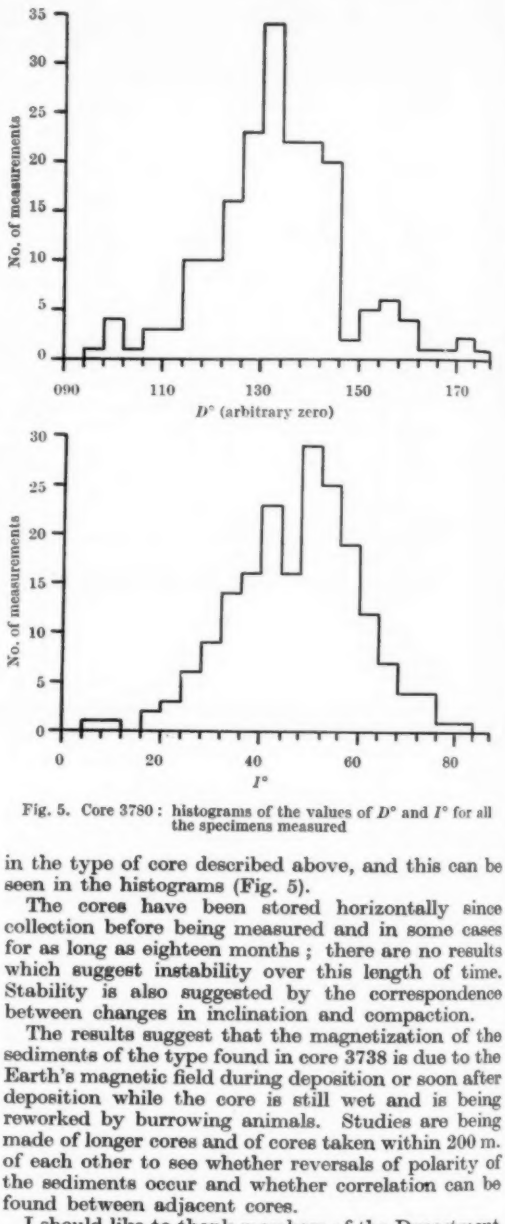

Fig. 5. Core 3780: histograms of the values of $D°$ and $I°$ for all the specimens measured

in the type of core described above, and this can be seen in the histograms (Fig. 5).

The cores have been stored horizontally since collection before being measured and in some cases for as long as eighteen months; there are no results which suggest instability over this length of time. Stability is also suggested by the correspondence between changes in inclination and compaction.

The results suggest that the magnetization of the sediments of the type found in core 3738 is due to the Earth's magnetic field during deposition or soon after deposition while the core is still wet and is being reworked by burrowing animals. Studies are being made of longer cores and of cores taken within 200 m. of each other to see whether reversals of polarity of the sediments occur and whether correlation can be found between adjacent cores.

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LETTERS TO THE EDITORS

ASTROPHYSICS

Gravitational Red Shift of Hydrogen 21-cm. Radiation as a Method to measure Galactic Gravitational Potential

THE 21-cm. hyperfine emission from the neutral hydrogen atom has an exceedingly narrow natural width, corresponding to a transition probability of $2{\cdot}84 \times 10^{-15}$ sec.$^{-1}$. Consequently, in principle, small variations in its frequency resulting from gravitational effects offer a method to measure gravitational potential in our Galaxy, provided that they are not too small compared with the temperature broadening. The galactic disk is well known to emit 21-cm. radiation, and from its observed Doppler shifts the radial dependence of its rotational velocity has been deduced. Because the true Doppler shifts of galactic rotational motion are large, it may be difficult to detect the expected gravitational shift, which also looks like a Doppler shift. But, in principle, the two effects may be separated because the true Doppler shifts have opposite signs at the same radius on opposite sides of the galactic centre, whereas the gravitational frequency shift has the same sign.

Added to the true Doppler shift, and the gravitational frequency shift, there is the temperature broadening of the 21-cm. line. For radiation emitted near the centre of the galaxy ($R \leq 1$ kpc) which propagates out to the Earth ($R = 8{\cdot}2$ kpc) the true Doppler shift has an average value of about 25 km./sec., and the temperature broadening is about 1·0 km./sec. corresponding to a temperature of 150° K. for neutral hydrogen.

Assuming the numerical values[1] at present accepted for the galactic gravitational potential, we compute the gravitational frequency shift for this radiation to be ~0·7 km./sec. Using the usual gravitational shift formula[2]:

$$\frac{\Delta\nu}{\nu} = \frac{\varphi_2 - \varphi_1}{c^2}$$

where φ_2 and φ_1 are the potentials at the point of emission and absorption respectively.

This frequency shift is equivalent to a Doppler shift resulting from a relative velocity v:

$$\frac{\Delta\nu}{\nu} = \frac{v}{c}$$

Consequently, the apparent Doppler shift velocity equivalent to the gravitational frequency shift is given by:

$$v \simeq \frac{1}{c}(\varphi_2 - \varphi_1)$$

and is positive (shift to bluer frequency) or negative (shift to redder frequency) accordingly as the photon comes to the Earth from a region of higher or lower gravitational potential. From the hypothesis that the galactic gravitational potential increases with increasing radius it follows that photons coming to us from near the centre of the Galaxy are red shifted whereas those coming from radii larger than 8·3 kpc are blue shifted.

Now let the potentials[1] be taken as $|\varphi_1| = 2{\cdot}9 \times 10^{15} \frac{\text{cm.}^2}{\text{sec.}^2}$ at $R_1 = 0$ kpc and $|\varphi_2| = 0{\cdot}82 \times 10^{15} \frac{\text{cm.}^2}{\text{sec.}^2}$ at $R_2 = 8{\cdot}2$ kpc, where we have multiplied by a factor (Schmidt, Martin, private communication) of 2 to account for a revised value of the total galactic mass. Then the equivalent velocity is:

$$|v| = \frac{1}{3} \times 10^{-10}[2{\cdot}9 - 0{\cdot}82] \times 10^{15} \frac{\text{cm.}}{\text{sec.}} = 0{\cdot}7 \text{ km./sec.}$$

If the galactic mass or galactic diameter should be different from the presently accepted values (ref. 1 and Schmidt, Martin, private communication) the equivalent velocity measured would differ from the value computed here.

A determination of the equivalent velocity for some region of the Galaxy measures the difference in gravitational potential between the point of emission and the Earth, and so gives independent information on the mass of the Galaxy. However, the effect is small, and will require to be detected against a background of large rotational Doppler shifts. In principle, this may be done in the following way, assuming the matter of the disk to be distributed symmetrically with respect to the galactic centre. Suppose one integrates all observed Doppler shifts, weighted by observed relative intensity, over an angular interval symmetric with respect to the galactic centre, $\vartheta \leq \theta \leq -\vartheta$, where θ is the angle between the direction of observation and the direction of the galactic centre. Then the sum of terms coming from all true Doppler shifts should add to zero, because these are positive and negative accordingly as θ is positive and negative, whereas the terms arising from gravitational shifts have always the same sign, and consequently add. The resultant sum when divided by the integral of total amount of neutral hydrogen present in that region is equal to the average gravitational shift in that region. If the effect is too small to measure one may nevertheless be able to determine an upper limit for the galactic mass.

There are, of course, various other effects which can distort the above simple approach and which may have to be taken into account such as the motion of the Sun, and possible errors in the determination of the Galactic centre.

The first might be treated in the following way. Assume the distribution of mass is symmetrical with respect to the line between Earth and galactic centre. Let the integral I over the given angular interval 2ϑ, symmetrical with respect to the galactic centre, be plotted versus ϑ for various heights of observation above, in and below the galactic plane, both in the direction of the galactic centre and in the opposite direction. In principle, these sets of data are sufficient to allow determination of the velocity of the solar system in the galactic plane with respect to the galactic centre, because resulting linear effects change sign for the two sets of data.

If the centre of the galaxy x_0 has been incorrectly identified, its effect may be minimized as follows. Compute I(2ϑ) for various assumed positions of the centre, on both sides of x_0; then integrate I(2ϑ) over x. The resultant depends on the gravitational red shift, and the error caused by wrong choice of

centre is $\sim(\Delta x_0)/2x$, where $2x$ measures the region of integration and Δx_0 measures the error in locating the centre.

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Measurement of Magnetic Fields in Chromospheric Flares

Spectra of two great chromospheric flares taken by the flare spectrograph at Ondřejov[1] show an evident splitting of the D_1 emission line of Na I which is attributed to a magnetic field existing in that part of the chromosphere where the sodium lines are formed. This explanation is supported by the following facts:

(1) Only the D_1 line is split into two components, while no effect can be found for the D_2 line (Fig. 1). Were the effect due to another physical reason independent of the magnetic field, such as self-absorption, it would have been found for both lines of the sodium doublet.

(2) For one of the flares the ultra-violet part of the spectrum was also photographed, and the same effect can be found for the λ3706 line of the third doublet of Ca II, the Zeeman pattern of which is identical with that of the D_1 line. Values of the magnetic intensity calculated from the Na I and Ca II lines, respectively, are in a good agreement (Table 1).

Apart from these two doublets our plates contain one more line only, for which the Zeeman splitting might be found without any polarization equipment, namely, that of the first doublet of Al I, λ3944. The emission in this line, however, is less intense and consequently the splitting could not be recognized in this case.

(3) Both these flares were photographed above a sunspot with a rather high magnetic field. No effect of this type has been found for flares outside the spots.

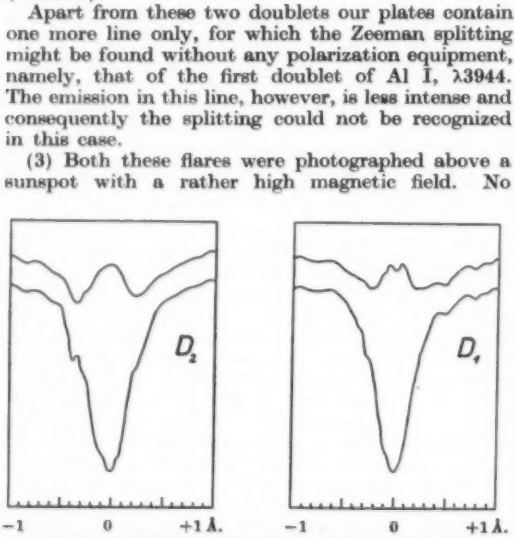

Fig. 1. Photometrical tracings of the D_1 and D_2 lines of sodium in the flare above a spot (upper curve) and in the photosphere close to the flare (lower curve). The D_1 emission is split by the magnetic field; the D_2 emission is partly absorbed on its red wing by the λ5890·2 line of water (March 29, 1959)

Table 1. Resulting Intensity of Magnetic Fields on March 29 (Spectra taken at 7 hr. 53 min and 56 min.) and on August 18 (Spectra taken at 10 hr. 34 min., 39 min. and 41 min.)

Line	Method	Splitting	Intensity $g = 4/3$ gauss	Intensity $g = 1$ gauss
March 29				
D_1	tracing	0·110 Å.	2,500	3,400
D_1	visual	0·117 Å.	2,700	3,600
August 18				
D_1	tracing	0·121 Å.	2,800	3,700
D_1	visual	0·134 Å.	3,100	4,100
λ3706	visual	0·054 Å.	3,200	4,200

The flares considered are: the first one on March 29, 1959, 7h. 46m.–9h. 30m., maximum phase at 7h. 43m., importance 2, position 17 N., 36 E., maximum H_α line width 4·0 Å., maximum H_α central intensity $\sim$ 125 per cent of the continuum[2]. Its part was projected on a spot, the maximum magnetic intensity of which was ascertained to 2,500 gauss on March 30, and 2,400 gauss on March 31 (ref. 3). No magnetic measurement was at our disposal on the day of the flare appearance. The second flare was observed on August 18, 1959, 10h. 13m.–12h. 35m., maximum phase between 10h. 25m. and 10h. 31m., importance 3, position 12 N., 32 W., maximum H_α line-width $\geqslant$ 5·6 Å. Measured maximum magnetic intensity of the spot associated was ascertained to 2,500 gauss on the day of the flare appearance and 3,100 gauss on August 19 (ref. 3). Spectra of both the flares were photographed by Miss Růžičková.

Fig. 1 presents profiles of the sodium D_1 and D_2 lines in the spectrum of the flare of August 18, traced by a Khol recording microphotometer. The linear dispersion was 1 Å./mm. and the resolving power 10^5. In the ultra-violet region the dispersion was 0·67 Å./mm.

The splitting was measured by two methods: from the tracings recorded, and visually from a projection of the negatives enlarged twenty times. The resulting values are given in the third column of Table 1. The splitting of the Ca II line was too small to be distinguished by a microphotometer tracing.

Due to the fact that the σ and π components are not separated, the determination of the magnetic intensity is rather uncertain. As both the flares appeared not far from the centre of the solar disk and directly over sunspots, the path of the radiation can be assumed as parallel with the magnetic lines of force. In such a case we may consider the σ components only, and we obtain the values of intensity given in the fourth column of Table 1. As, however, metallic emission lines of flares seem to be formed rather high in the chromosphere[4], we cannot be sure about the course of lines of force in the emitting area and weaker π components can also be present. Therefore, we add as the upper limit the case of $g = 1$ in the last column of Table 1.

Although the precision of our measurements, made without any polarization equipment, is not very high, one can be sure that during these flares strong magnetic fields—approximately of the same order as in the photospheric part of the sunspots—existed rather high in the chromosphere. This supports former conclusions[5] that the gradient of the magnetic intensity above sunspots is extremely low. As always, the most intensive regions of flares were photographed by the Ondřejov spectrograph; our result also shows

that even very bright parts of chromospheric flares can exist directly in those parts of the solar atmosphere where very strong magnetic fields are present.

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GEOPHYSICS

Stress-Dependent Magnetization in Some Quartz-Dolerites

When non-axially magnetized cylindrical specimens of a quartz-dolerite have been axially compressed in an axial magnetic field of the order of the Earth's, their natural remanent magnetism vectors have changed towards the ambient field direction.

The empirical functions :

$$K = \frac{P_\varphi - P_{90}}{\tan 90 - \varphi} \pm 7 \text{ per cent} \qquad (1)$$

and :

$$I_T = \frac{I_A}{\tan 90 - \varphi} \pm 10 \text{ per cent} \qquad (2)$$

fit the measured changes where P_φ is the pressure applied to produce a vector making an angle φ with the field and compression direction, K is a parameter dependent upon the magnetic minerals and the ambient field-strength, and I_A and I_T are the axial and transverse components of the natural remanent magnetism intensity.

An example for specimen number 18*H* is given in Table 1.

Table 1

P_φ (kgm./cm.²)	$90 - \varphi$ (°)	Tan $90 - \varphi$	I_A (arbitrary units)	I_T	Field oersteds
0·0	−59	−1·68	−17·0	10·0	1·8
127·2	−49	−1·15	−13·8	12·0	1·8
254·2	−31	−0·61	− 6·1	10·0	1·8
381·6	−14	−0·25	− 2·9	11·5	1·8
508·8	+21	+0·38	+ 4·2	10·8	1·8
636·0	+55	+1·43	+13·0	9·0	1·8

Putting tan $90 - \varphi = y$, $P_\varphi = x$ and $K = 1/b$, then the least squares solution for the straight line $y = bx + c$ leads to :

$$K_{1\cdot8} = 217 \pm 13$$

similarly :

$$I_T = 10{\cdot}5 \pm 1{\cdot}0$$

The error in K is equivalent to an error of 4°–5° in φ, about twice the repeatability of a measurement, a difference attributed to magnetic inhomogeneities accentuated by the stress treatment. Results for several specimens from the same dyke locality in fields up to 2·4 oersteds and pressures up to 636 kgm./cm.² (that is, 30–50 per cent of that to produce fracture) are given in Table 2.

Stereograms of natural remanent magnetism vectors for a number of cores from specimens 15 and 18 (Fig. 1) are examples of an unstable and a stable type

Table 2

Specimen	Core	Field	K
15	*H*	0·6	295 ± 20
15	*C*	1·2	98 ± 3
15	*C*	1·8	55 ± 5
15	*G*	2·4	63 ± 6
18	*H*	0·6	590 ± 90
18	*H*	1·2	270 ± 10
18	*H*	1·8	217 ± 13
18	*B*	1·2	590 ± 25
18	*B*	2·4	344 ± 11
20	*I*	0·6	575 ± 80
21	*B*	1·8	147 ± 15

respectively. Their K-parameters are a measure of their stabilities under conditions of geological significance. Specimen 18 has retained its magnetization in the original Permian thermal remanent magnetism direction[1]. The present field makes angles, measured almost in the meridian, of 90° and 115° with the natural remanent magnetism of specimen 18*H* and the Permian field respectively. This indicates the maximum geological compression (P_{90}) on the core in the present field direction since :

$$P_{115} - P_{90} = 600 \tan (90\text{–}115)$$

so

$$P_{90} = 300 \text{ kgm./cm.}^2, \text{ where } P_{115} = 0$$

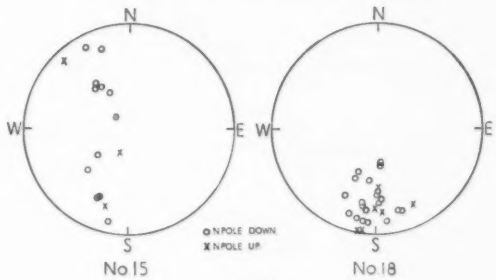

Fig. 1

An experiment on one specimen shows that the K_{TRM} is three or four times greater than its K_{NRM} in the Earth's field. This suggests that the stress dependence is due to unmixing of higher temperature magnetic phases[2]. One specimen showed a decrease of K_{NRM} after repeated stress treatment. It is hoped to continue these measurements over a wider range of field and stress and rock types and to examine the magnetic minerals optically.

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Atmospherics on 20 kc./s. at the Time of Local Auroræ

A continuous registration of atmospherics on 20 kc./s. has been in action, during the night hours, at our Geophysical Observatory since July 1959, with some interruptions during December 1959–February 20, 1960.

Every time (30 cases to date) that a strong aurora was seen, the 20-kc./s. registration showed distinct intermittent and violent bursts, some of which saturated the receiver and sent the recording pen

off scale for several minutes. The intensity was greater than 60 db. across 300 ohms.

At other times we have recorded similar sporadic bursts of atmospherics when the skies were overcast; but whether there was an aurora we cannot say since no catalogue of locally visible auroræ could be obtained. As a private institution we cannot afford to have an observer outside in the open and with sub-zero temperatures all the year round. A continuously radiating radar is also out of the question owing to regulations of the Telecommunications Administration.

Nevertheless, notwithstanding all these shortcomings we have the impression that auroræ of sufficiently strong intensity can, at times, beam earthward streams of protons or electrons into the lower stratosphere and upper troposphere. These ionized strips of the upper atmosphere could enhance the intensity of reflexion of atmospherics, originating in distant regions and recorded where the aurora is visible with its sudden variations of brightness and colouring. The ionization produced, if any, should last longer than the downward injections of auroral protons. The visible increases of intensity of the auroræ have not the same duration. Some last a few seconds, some several minutes, as do the bursts of atmospherics. The two phenomena, namely, the transient ionization of the upper troposphere and the intense bursts of the atmospherics, seem to be correlated in time.

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PHYSICS

Ferromagnetic and Antiferromagnetic Behaviour in the Second Transition Group

A 'pseudo-palladium' alloy containing 1 atomic per cent each of rhodium and silver in solid solution in palladium has been found to have a susceptibility strongly dependent on the magnetic field at low temperatures and to show hysteresis. At room temperature the susceptibility is accurately independent of the field and about 5 per cent greater than that of pure palladium.

A graph of magnetization against field is given in Fig. 1, and Fig. 2 shows the dependence on temperature of the apparent spontaneous magnetization (σ_0) derived from the high-field portions of the magnetization curves, where $\sigma = \sigma_0 + \chi H$.

It seems significant that σ_0 falls to a low value in the temperature-range where the susceptibility of pure palladium shows a maximum[1]. We have found a specimen of very pure palladium to show susceptibility independent of field; the magnitude of this susceptibility is also shown in Fig. 2, and it will be observed that it decreases steadily from the maximum value down to 5° K. (Since a less-pure specimen shows a marked increase below about 20° K., the higher value at 2° in the purer specimen is presumably associated with the residual impurities.) Palladium thus seems to possess some antiferromagnetic character, as discussed by Lidiard[2], and we suggest that when alloying takes place in which the mean number of electrons is kept constant, the basic interactions are little changed, but slight imperfections in the

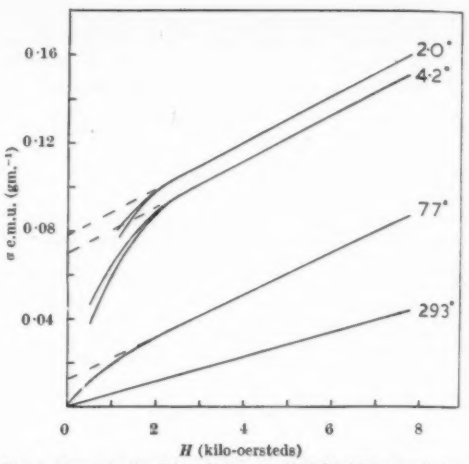

Fig. 1. Magnetization (σ) against magnetic field (H) for a palladium 1 per cent silver 1 per cent rhodium alloy

antiferromagnetic order give rise to a ferromagnetic moment. An explanation of this type has been put forward for the weak ferromagnetism of α Fe_2O_3 (ref. 3). More direct evidence of antiferromagnetism is being sought by neutron diffraction. The electrical resistance of the pseudo-palladium alloy shows no marked anomaly in the temperature-range concerned; but a negative magneto-resistance is found in low fields at 4·2° K.

The co-existence of ferromagnetism and antiferromagnetism might lead one to expect exchange anisotropy effects like those in the Co–CoO system (ref. 4), or in the perhaps more analogous disordered Ni_3Mn alloy (ref. 5), but we have not found the palladium alloy to be appreciably affected by cooling in a magnetic field.

In an alloy containing 5 per cent each of rhodium and silver, the dependence of the susceptibility on the field appears at lower temperatures, but is well established at 4·2° K.; although the susceptibility of a binary alloy of palladium with 5 per cent rhodium, which has a very enhanced susceptibility at 20° K.

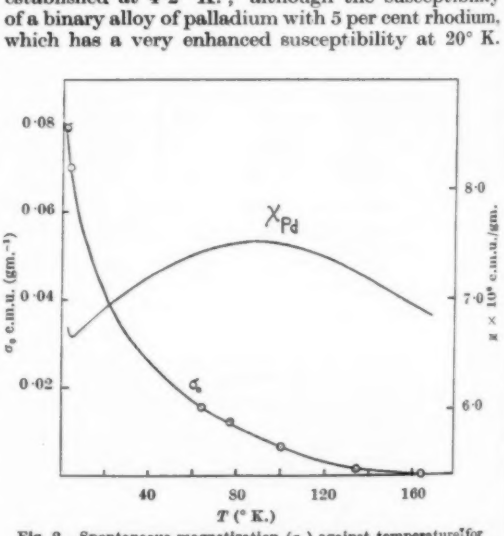

Fig. 2. Spontaneous magnetization (σ_0) against temperature for a palladium 1 per cent silver 1 per cent rhodium alloy and magnetic susceptibility (χ_{Pd}) of pure palladium

(ref. 6), has been found by us to show only an extremely small dependence upon field at helium temperatures. This would suggest that rhodium alone depresses the susceptibility maximum of pure palladium, thereby raising the low-temperature susceptibility but preventing the appearance of local ferromagnetism. A palladium 1·6 per cent silver alloy also shows no anomalous behaviour at 4·2°.

This investigation is being extended to related alloys, and a fuller account will be published elsewhere. We thank the Mond Nickel Co. (Precious Metals Division) for the provision of the alloys, the Royal Society and the Atomic Energy Research Establishment, Harwell, for financial support, and Mr. R. V. Bellau for assistance with the electrical measurements.

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Direct Observation of Surface Contamination formed in Demountable Vacuum Systems

The visible contamination of specimens examined in the electron microscope is the result of a reaction between the electron beam and matter adsorbed on the irradiated surface. This adsorbed material is known to consist of hydrocarbon molecules[1], though it may also contain some water molecules; it exists on surfaces in all demountable vacuum systems. The layer is troublesome in many experiments and processes involving such systems, but evidence of its presence is only indirect and little is known about its thickness or composition. It is particularly noticeable in high-resolution shadow-casting for the electron microscope (unpublished work), since it limits the resolution by causing a fine background structure. In the course of an investigation of this structure, a method was found for studying the adsorbed layer directly, and also for estimating its thickness. It was found that the layer was visible in the electron microscope when viewed end-on and sandwiched between two carbon films (see Fig. 1). The procedure is carried out as follows.

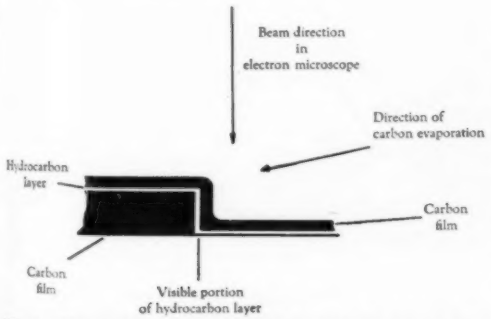

Fig. 1. Diagram showing the manner in which a contaminant layer, deposited from a vacuum system, can be viewed directly in the electron microscope

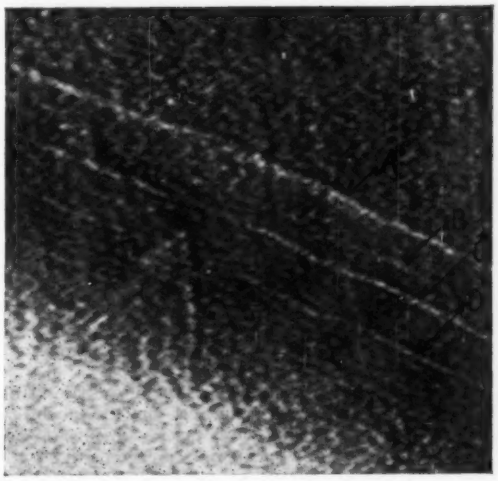

Fig. 2. A contaminant layer deposited from a vacuum system viewed end-on in the electron microscope; each white line represents a different layer (see text). (× 400,000)

A carbon film about 300 Å. thick is deposited on a glass slide and floated on to a water surface. A second carbon film about 100 Å. thick is deposited on a freshly cleaved mica surface. A drop of water is placed on the coated mica, and a few small pieces of the floating carbon film transferred to the drop with a very fine glass rod. The excess water is removed with filter paper and the thick carbon film allowed to dry on to the thinner. The second film provides vertical steps. A further carbon film is now evaporated against one of the steps at an angle of 26½° to the horizontal as shown in Fig. 1, the direction of deposition being perpendicular to the line of the step. The combined films are floated on to water, and the portion containing the step mounted on a grid. The step edge is located in the electron microscope, and a thin line transparent to electrons and separating the final carbon deposit from the step face can be clearly seen. If the orientation of the specimen is such that the direction of the incident electron beam is not parallel to the step face, then the line disappears, as might be expected.

A simple experiment shows that the thickness of this line depends upon the time for which the step face is exposed to the atmosphere in the pumping plant. This is carried out by depositing several secondary carbon layers, in a series of short bursts spaced by varying intervals of time. In this way the change in thickness can be studied in a single electron micrograph, such as that shown in Fig. 2. Here, the material in the line marked *A* was deposited while the plant was pumped down from atmospheric pressure and then evacuated with the diffusion pump for 30 min. The line *B*, only just visible, was formed in an interval of 1 sec. between two depositions of carbon, the line *C* was formed in 20 min., and *D* in 10 min. During these intervals, the system (pumped by a 'Metrovac' 03*B* diffusion pump, with no cold trap, using 'Apiezon *B*' oil) was at a pressure of about 10^{-4} mm. mercury. It can be seen from the electron micrograph that the width of the line depends on the time of exposure to the atmosphere in the system. This indicates that the line transparent to electrons represents an end-on view of a layer of material

which originates in the pumping plant. The fact that the layer is much more transparent to electrons than a similar thickness of carbon shows that it contains a high proportion of atoms with a scattering power less than that of carbon, which would be the case if the layer consisted of hydrocarbon molecules.

The thickness of layer *A* is about 25 Å. and that of layer *B* about 10 Å. This suggests that layer *B* is monomolecular, since it is probable that the molecules would be about 10 Å. in diameter; a monolayer can thus form in the system in 1 sec., but it appears that a dynamic equilibrium is reached within 20 min. when a layer two to three molecules thick has been deposited.

The direct examination of contaminant layers in this way could be useful in determining the efficiency of a vacuum system with regard to the amount of hydrocarbon vapour present.

It has been found that the technique described above can be used as a method for measuring the thickness of very thin evaporated films to a high degree of accuracy. It can be seen from Fig. 2 that the lines, which are very sharp, can be used as reference marks for measuring the thickness of the carbon deposit. For example, the distance between lines *C* and *D* is 7 mm. thick on the micrograph, representing a film thickness of 175 Å. This will equal the thickness of carbon deposited on a substrate placed horizontally beside the step, since the angle of evaporation in this case was 45° (see Fig. 1). By lowering the angle of deposition, the ratio of the horizontal to vertical thickness will be altered geometrically so that a greater thickness exists on the vertical step face than on the horizontal target. With a suitable angle a thickness 'magnification' of about three times could be attained without difficulty on the step face, so that a measurement of 60 Å. in the electron microscope to an accuracy of 9 Å. would give a target thickness of 20 Å. to within 3 Å.

A preliminary comparison between thickness measurements carried out on the same carbon film using an optical method and that described here gives a reasonable correlation:

Optical method	Electron microscope method
223 Å.	206 Å.
140 Å.	110 Å.
121 Å.	118 Å.

The optical method employed a shearing interferometer microscope[2], which is at least as accurate as the conventional Fizeau fringe technique[3].

It has been found that the electron microscope method is satisfactory for silicon monoxide and platinum/carbon[4] films; aluminium films have also shown promising results.

I thank Miss P. Rush for carrying out the comparative measurements, and Dr. T. E. Allibone, director of the Laboratory, for permission to publish this communication.

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Rare Modes in the Spontaneous Fission of Californium-252

Californium-252, a man-made trans-uranic element, having an α-particle half-life of 2·2 yr., undergoes spontaneous fission. Approximately one fission occurs per 38 α-particles, and the material is therefore well suited to an investigation of the possibility of rare modes of spontaneous fission.

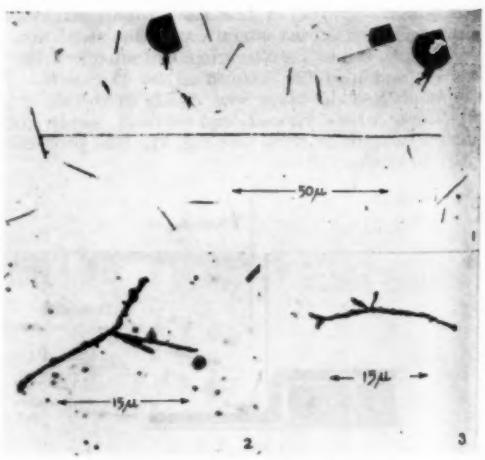
In slow-neutron fission[1,2], fast-neutron fission[3] and photofission[4,5], two rare fission modes have been established. In one the emitted particle is long-range and uniquely an α-particle; in the other, short-range particles, apparently light elements, appear to be emitted in the process. There is also, in slow-neutron fission, some evidence for fission into three particles of approximately equal mass and kinetic energy, but this is not unambiguous[6].

Observation of the quaternary fission of uranium-235 was claimed in 1946 by a French group[7], but later work in this laboratory[8] showed that, if it occurred, the frequency was much less than that estimated from the French investigation.

In the present experiment, where minute traces of californium-252 were incorporated into Ilford K_5 and E_1 emulsions, the conditions of observation were more favourable than in any of the earlier nuclear emulsion studies. Since the plates required no irradiation, they contained only the californium-252 fission and α-tracks plus the usual slight background from inevitable radioactive inclusions. Random association of tracks yielding 'spurious' events was therefore greatly reduced and could be virtually eliminated by measurement of a range of distributions of tracks in the emulsion.

In a study of 50,000 binary events in these emulsions the following types of event have been recorded:

(1) 179 cases have been observed of ternary fission into two heavy fragments and a long-range α-particle; the frequency is 1 per 280 (± 25) spontaneous binary fissions. The mode appears to be significantly more frequent than in the case of slow-neutron fission of uranium-235, uranium-233 or plutonium-239 (ref. 8). An example is shown in Fig. 1.



(1) Ternary fission of californium-252
(2) Probable quaternary fission of californium-252
(3) Projection of recoils in emulsion shortly after fission giving appearance similar to a quaternary fission

(2) Eight good examples and four additional possible cases of fission into four heavy fragments (Fig. 2) have been observed. Apart from quaternary fission, the only other possible explanation for these events is that they arise from recoils projected in the emulsion by the pair of fission fragments within ½μ of the origin. Two experimental results oppose such an explanation. Although events of this general type do occur (as is indicated by Fig. 3 but where the 1μ spacing between the forks clearly eliminates the event as quaternary), their observed frequency is too low to explain the four-particle events. Moreover, if scattering accounted for such events, then in the earlier study of 600,000 uranium-235 binary fissions[5], some 100 such events should have been observed; in fact only 2 were recorded. We therefore believe the events to be true spontaneous quaternary fission, the frequency being roughly 1 per 5,000 binary fissions.

(3) Three events of the type Fig. 4 (and see enlargement of origin, Fig. 5) have been observed. Again these might be explained as an event of type 1 with a recoil occurring near the origin, and such spurious cases do occur as indicated in Fig. 6. However, during our earlier work where more than 10^6 binary fissions were examined, only one other example of such an event was observed. These events may, therefore, represent a mode of spontaneous quaternary fission involving emission of a long-range α-particle and a short-range light nucleus in addition to the two fission fragments.

(4) As in previous experiments, a considerable number of events are observed which could be interpreted as ternary fission, the third fragment being a short-range light nucleus. The frequency of occurrence of such tracks at the origin appears to be greater than would be expected from Rutherford scattering. In addition to these events, which occur at a rate of 1 per 80 (± 20) binary fissions, others have been observed which could be ternary fission into three roughly equal parts. Analysis of the type employed by Catala *et al.*[6] indicates that many of these arise through fission fragments colliding with silver or bromine nuclei in the emulsion. However, it does not exclude all, and it could be that this mode of fission exists in californium-252.

The experiments are continuing, and will be reported in detail later. We wish to thank Prof. E. M. McMillan and Dr. S. G. Thompson, of the University of California, who provided the californium for these experiments.

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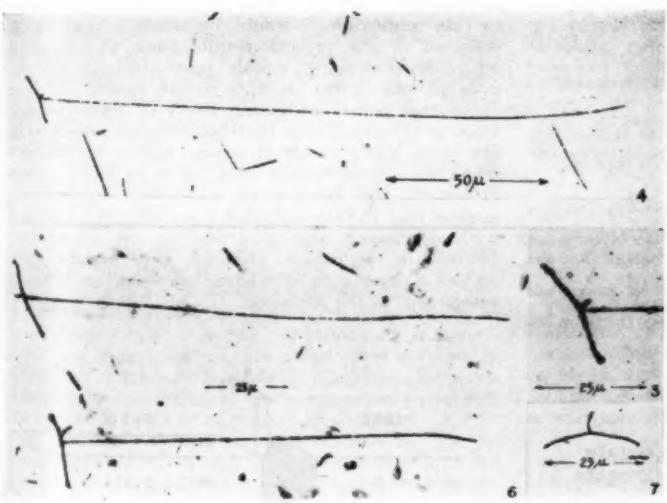

(4) Possible fission into two heavy fragments, a long-range light particle and a short-range light nucleus
(5) Enlargement of origin of (4)
(6) Examples of a ternary event of type (1) with a recoil track close to origin, easily distinguishable from (4)
(7) Case of possible ternary fission into three roughly equal fragments

The Second Virial Coefficient of Methane at Low Temperature

The second virial coefficient of methane has been determined over a range of temperatures from 108° to 250° K. by means of an apparatus which is described elsewhere[1].

The principle of the experiments consists in measuring the difference in the expansion of volume of the gas under study and a reference gas. In our experiments we chose hydrogen as reference substance. The working pressure is less than one atmosphere; this allows us to neglect coefficients of higher order than the second in the expansion of the compressibility factor pV/nRT, where p is pressure V, is volume, R is the gas constant, T is absolute temperature and n is number of moles.

Methane was obtained by distillation at low temperature of commercial 'pure grade' gas. The melting of the solidified sample we used took place over a range of less than 1×10^{-3} °K. The vapour pressure at the triple point was 87·58 mm. mercury. The value of 87·60 ± 0·10 mm. mercury was found at the National Bureau of Standards of Washington by Armstrong, Brickwedde and Scott[2] with a carefully purified sample. The purity estimated from the range of freezing point was better than 99·9 per cent (ref. 3). The hydrogen used was 'research grade' gas of 99·99 per cent purity.

Values obtained for methane are listed in Table 1. In Fig. 1 these values are reproduced for compari-

Table 1

Temperatures (° K.)	Measured differences between the second virial coefficients of methane and hydrogen $B_{CH_4}-B_{H_2}$ (c.c./mole)	Second virial coefficients of hydrogen (c.c./mole)	Deduced values for the second virial coefficient of methane (c.c./mole)
108·45	− 365·27 − 361·82	+ 0·280	− 364·99 − 361·54
125·2	− 271·60 − 272·54	+ 3·625	− 267·97 − 268·92
149·1	− 194·96 − 194·56	+ 6·923	− 188·04 − 187·64
186·4	− 136·25 − 136·35	+ 10·15	− 126·10 − 126·20
223·6	− 84·72 − 94·79	+ 12·099	− 82·62 − 82·69
249·3	− 81·56 − 81·41	+ 13·033	− 68·53 − 68·38

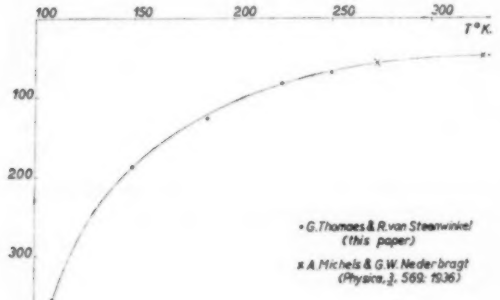

Fig. 1

son with those obtained by A. Michels and G. W. Nederbragt[4] at higher temperatures. The agreement between the two curves is excellent.

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ENGINEERING

Dependence of Cement-Aggregate Bond-Strength on Size of Aggregate

In a recent study[1] the strength of the bond between Portland cement paste and sawn aggregate surfaces was found to be less than that of the paste matrix. In some instances therefore, for example in the case of the flexural strength of plain concrete containing smooth aggregate, cement-aggregate bond is likely to be the factor controlling strength. Although several aspects of the mode of failure of concrete could be explained by this concept, it was soon clear that a number of others which should also have been explained were, in fact, anomalous. The form of the departures from expected behaviour suggested that cement-aggregate bond-strength might depend on aggregate size, and the following experiments were therefore performed to check this possibility.

Cubes of water-saturated basalt-aggregate, with edge-lengths ranging from 0·5 to 3·0 in., were bonded to a paste of ordinary commercial Portland cement, cured for 24 hr. in the moulds at 70° F., and afterwards stored under water at 70° F. for six days. Cement paste, with a water/cement ratio of 0·35 by weight, was bonded to the aggregate cube face to be tested, while the opposite face, previously grooved with a diamond saw, was bonded to paste with a water/cement ratio of 0·31. These conditions ensured preferential failure at the interface between aggregate and the 0·35 water/cement ratio paste when the composite beam was subjected to mid-point loading as shown in Fig. 1. The beam was immersed in water during testing[2], and the number of replications ranged from 20 for the ½-in. cubes, down to 10 for the 3-in. cubes. The mean coefficient of variation was 15 per cent.

The results (Fig. 2) show that with the square aggregate surfaces used here, bond-strength decreases with increasing size of aggregate, and that there is a linear relationship between cement-aggregate bond-strength and the logarithm of the reciprocal of the area bonded.

Although coarse aggregate and mortar are frequently considered to be the two phases of which concrete is composed it has also been argued that if the bond between cement paste and coarse aggregate is likely to fail, then the bond to fine aggregate would also fail, and that the two phases to be considered are cement paste and all aggregate, regardless of size. These alternative hypotheses have been debated in discussions[3,4] on the mode of failure of concrete and, in this connexion, it might be thought that extrapolation of the present results back to the point where bond-strength equals paste-strength (in the present case 2,000 lb./in.²) would decide between these two points of view. Such an extrapolation leads to the conclusion that bond failure ceases to be the most likely cause of tensile failure of concrete when the aggregate size falls below 14 B.S.S. mesh. However, the results of additional experiments suggest that the rate at which bond-strength increases with decreasing aggregate size is not maintained below ½-in. aggregate, although experimental difficulties in this region have so far prevented an accurate assessment of the situation.

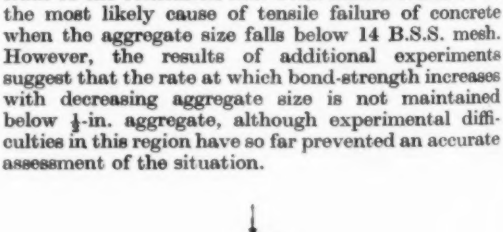

Fig. 1

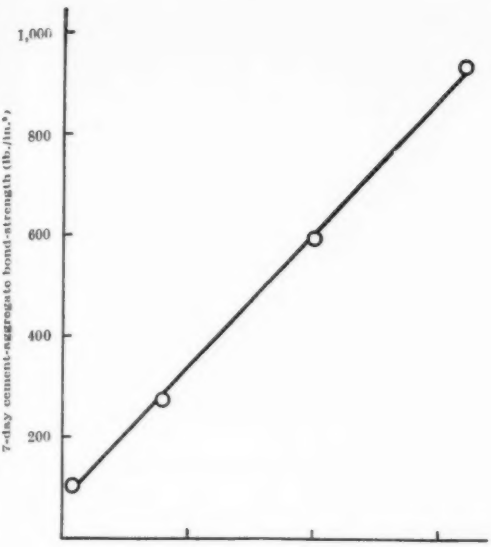

Fig. 2

Thus, instead of favouring the view that the transition size between coarse and fine aggregate has special significance in the phenomenon of failure in concrete, or the alternative view that bond is equally likely to fail at the surface of either coarse or fine aggregate, the present results indicate that there are likely to be specific zones of weakness in concrete, and that these zones are located at the junction between the paste matrix and the largest aggregate pebbles present. With this hypothesis as a basis, explanations can be advanced for a number of experimental observations concerning the strength of concrete, for example :

(1) The flexural strength of concrete is less than the flexural strength of the corresponding mortar[4]. This result would be expected because, in the transition from concrete to mortar, the weakest bonds have been eliminated by exclusion of the largest aggregate pebbles.

(2) In an investigation[5] on the strengths of concretes containing coarse aggregate with maximum sizes ranging from $\frac{3}{8}$ to $2\frac{1}{2}$ in. it was found that in spite of the progressive reduction in mixing water requirement as maximum size of coarse aggregate increased, increasing the maximum size of aggregate above $\frac{3}{4}$ in. did not necessarily increase either flexural or compressive strength. Lowest strengths were in fact obtained with concrete containing $2\frac{1}{2}$ in. maximum size aggregate. These effects are apparently caused by introducing areas of exceptionally weak cement-aggregate bond, as a consequence of increasing the maximum size of aggregate in the mix.

(3) In the investigation[5] mentioned in (2) the reproducibility of strength tests was found to be poorest for concrete containing the largest maximum size of aggregate. The dependence of cement-aggregate bond-strength on aggregate size could explain this behaviour as follows. Taking an extreme case, such as that of specimens used for flexural strength tests on mixes containing the largest pebbles, it is apparent, first, that these large pebbles, which develop the weakest cement-aggregate bond, will be relatively few in number, and secondly, that whether or not a cement-aggregate interface on one of the large pebbles is suitably orientated and in that part of the beam which is in maximum tension, could have an appreciable effect on the strength of the specimen, and could be the cause of the poor reproducibility of these particular tests.

A possible reason for the bond-strength size effect is that in cement paste the process of hardening may be accompanied by dimensional changes which are large enough to give rise to considerable internal stress in the paste film in contact with the aggregate surface, when this tendency of the paste to move is opposed by the aggregate. The larger the surface bonded, the greater the internal stress and the smaller the apparent bond-strength. A rather similar situation applies in the case of the restraint which different sizes of aggregate exert on Portland cement paste during drying shrinkage[6].

For a number of reasons it is considered that the bond-strength size effect in concrete will probably not be as marked as that shown by isolated cement-aggregate interfaces such as those studied here. For example, near the region where maximum tensile stress exists in a beam tested in flexure the orientation of the largest aggregate surfaces may be such that these comparatively weak areas of cement-aggregate bond are subjected only to low tensile stress. Also, the largest aggregate pebbles are not embedded in neat cement paste, but in a matrix the dimensional changes of which are likely to be reduced by the stabilizing influence of the smaller pebbles and sand grains which it contains.

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A Historical Note on the Reciprocal Theorem and Theory of Statically Indeterminate Frameworks

Opinions seem to vary concerning the origin of the reciprocal theorem. Thus, in his book "Mathematical Theory of Elasticity" (4th edit. 1927), A. E. H. Love attributed the theorem to E. Betti (*Il nuovo Cimento*, ser. 2, 1872), but stated that it is a special case of a more general theorem due to Lord Rayleigh (*London Math. Soc. Proc.*, 4, 1873). In his book "Theory of Sound" (Vol. 1, 2nd edit. 1894), however, Rayleigh also acknowledged the reciprocal theorem as due to Betti. Neither Love nor Rayleigh connected Maxwell's name with the theorem although it is widely known as "Maxwell's Reciprocal Theorem". In fact, Maxwell did include a statement of a form of the reciprocal theorem in his paper "On the Calculation of the Equilibrium and Stiffness of

Frames" (*Phil. Mag.*, **27**, 1864). It is, no doubt, due to this work, which appeared before the relevant work of Betti and Rayleigh, that Maxwell is nowadays given credit for the theorem, and it is interesting to note the neglect of Maxwell's paper by Rayleigh and Love.

Another authority whose work, in retrospect, had some bearing upon the reciprocal theorem was A. Clebsch (1833–72). Now, although Clebsch's book "Theorie der Elasticität fester Körper" (Leipzig, 1862) (which was translated into French and annotated by Saint-Venant and Flamant and published in Paris in 1883) was widely quoted by elasticians, including Rayleigh and Love, the chapter which is relevant to the reciprocal theorem seems to have escaped their attention. This is Chapter 8, the final chapter, which is concerned with systems of bars, that is, frameworks. Moreover, there seems to be no reference to this work in subsequent publications of engineering scientists, for Maxwell is regarded as the pioneer of statically indeterminate frame analysis. It seems likely, therefore, that, in common to some extent with Maxwell's paper (*loc. cit.*), this aspect of Clebsch's work seemed trivial to the mathematicians but forbidding to the engineers of his time. Thus, in Art. 90, Chapter 8, of his book, Clebsch dealt generally with the analysis of pin-jointed space frameworks with linear elasticity, and showed that the equations of equilibrium of the joints can be expressed in terms of their displacements and coefficients of elasticity, the latter being the stiffness coefficients. Clebsch noted the identity of the cross-coefficients, that is $a_{ij} = a_{ji}$, which expresses the reciprocal property of linear systems, though he does not seem to have stated the reciprocal theorem verbally. Navier, in his book "Résumé des Leçons données a l'Ecole des Ponts et Chausées sur l'Application de la Mécanique a l'Etablissement des Constructions et des Machines" (1826), gave the same basic method of analysing statically indeterminate elastic frameworks but did not develop it to the same extent as did Clebsch.

In recent years much attention has been given to the systematic analysis of linear elastic statically indeterminate frameworks in relation to the programming of digital computers for structural analysis. It is therefore interesting to note that for the majority of structural systems an approach using stiffness coefficients, identical to that used by Clebsch nearly a hundred years ago, is regarded as the most suitable for this purpose.

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METALLURGY

A Possible Origin of Exo-Electron Emission in Plastically Deformed Metals

The blackening of certain photographic emulsions by freshly fractured or abraded surfaces was first studied in detail by Russell in 1897 [1]. This phenomenon, the Russell effect, is now known to be a consequence of the formation of hydrogen peroxide on the freshly exposed metal surfaces [2]. More recent work by Grunberg [3] indicated that the formation of hydrogen peroxide is initiated, in the presence of water vapour and oxygen, by the emission of low-energy exo-electrons [4]. This emission received considerable attention by a number of Continental workers [5], and it is generally accepted that in the case of metals the electrons are emitted from crystal imperfections in the freshly formed or distorted oxide layer.

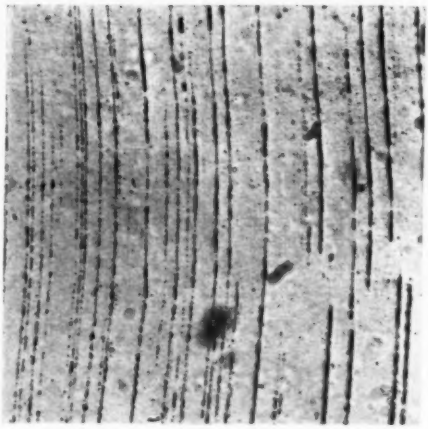

Fig. 1. The appearance of exposed emulsion at low magnification. Lines correspond to slip lines on the crystal surface. (× 140)

So far, only the macroscopic or integrated aspects of both the Russell effect and exo-electrons have been studied. We have observed, by the use of an autoradiographic stripping emulsion of high resolution, certain microscopic features of the Russell effect which may be useful in revealing the origin of both phenomena. The improved image resolution obtained by this technique was made possible by placing the emulsion in intimate contact with the metal surface.

High-purity zinc single crystal rods were electropolished, thoroughly cleaned, statically strained and the emulsion (Kodak *AR*10 stripping emulsion) then applied to the surface. Exposure times of 1 hr. were generally found adequate, provided the exposure was commenced within a few minutes of straining. On examination of the emulsion with an optical microscope, black lines were observed which corresponded exactly to slip-lines on the crystal surface. An example is shown in Fig. 1. Since the slip displacement varied around the circumference of the crystal, it was possible to deduce that the continuous black

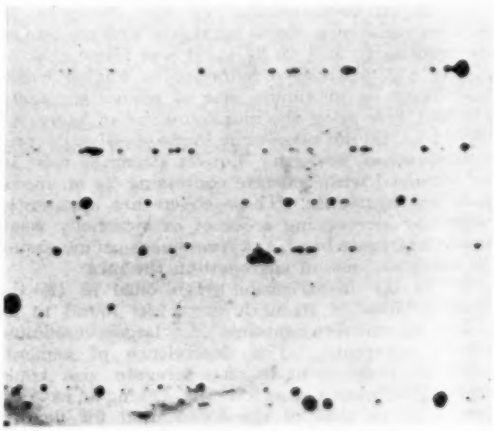

Fig. 2. Pattern obtained from slip lines of small displacement. Maximum useful magnification of emulsion. (× 940)

lines were associated with relatively large slip displacement. With decreasing slip displacement the lines first became discontinuous and then resolvable into rows of individual spots (Fig. 2). This latter configuration resembles the dislocation etch pits observed by one of us[6] along the slip lines of zinc single crystals.

The foregoing evidence shows that the Russell effect, and probably exo-electron emission, in plastically deformed metals originate from slip bands on the surface. The similarity between the patterns observed here and dislocation etch pits configurations further suggests that the centres of emission are the points where dislocations terminate at the surface of the crystal. It is possible that at such points the oxide film is highly distorted by the emergence of the dislocation, thus producing the imperfections necessary for exo-electron emission. This hypothesis is further supported by recent work reported by Young[7], who has shown that oxide nuclei are formed at dislocations.

The hypothesis is in agreement with previous observations that both the rate of exo-electron emission and the intensity of the Russell effect increase with increasing deformation[8]. It would be interesting to make a comparison of the rate of emission from two crystals of widely differing dislocation concentrations.

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Correlation of the Alternating Stresses required to initiate and propagate a Fatigue Crack in Mild Steel

Experimental results obtained from mild steel plates containing small edge cracks subjected to reversed direct stress loading (that is, zero mean load) have suggested that whether or not a crack grows is governed by the parameter $\sigma^3 l$ (σ = nominal alternating stress, tons/sq. in., l = length of edge crack, inches)[1]. If the value of $\sigma^3 l$ is greater than 5·5, a crack will grow; if less, it will remain dormant. It has been shown[1–4] that with certain notched specimens, non-propagating cracks may be present at the root of the notch of those tested at stresses equal to and below the conventional notched fatigue limit (that is, for specimens either remaining unbroken or being completely broken). When the geometry of the specimens is such that non-propagating cracks are present, the conventional notched fatigue limit is independent of the radius of the notch root and is equal to the alternating stress required to propagate the crack. This depends on the depth of the notch, for it has been shown[1] that the relationship $\sigma^3 l = 5{\cdot}5$ is applicable if l is taken as the depth of notch plus the length of non-propagating crack formed.

It is generally accepted that at zero mean load the fatigue strength of a notched specimen is greater than that given by the plain fatigue limit of the material divided by the geometric elastic stress concentration factor for the notch. Many attempts, usually related to the existence of the stress gradient at the root of the notch, have been made to account for this discrepancy; however, ignorance of the possibility of non-propagating cracks has led to much confusion. Isibasi and Uryu[4], however, differentiated between crack initiation and propagation; they found that for mild steel notched specimens, cracks formed at the root of the notch when the distribution of stress was such that over a distance of 0·002 in. in from the root of the notch the stresses were equal to or greater than the plain fatigue limit.

For zero mean load the material at the root of a notch is subjected to similar stress distributions on the tension and compression halves of the loading cycle; the material ahead of a crack, however, is subjected to stress concentration effects only on the tension half of the cycle. Thus when considering the intrinsic fatigue strength of the material ahead of a crack, the zero to tension value is appropriate. For the mild steel under consideration, this value is about 0–22 tons/sq. in. The yield stress of the material is about 19 tons/sq. in., and thus measurement of the plastic zone ahead of the crack in a plate specimen will give an approximate estimate of the length of material subjected to stresses greater than the plain fatigue limit. Frost and Dugdale[5] made such measurements on annealed (furnace-cooled from 800° C.) mild steel sheet specimens and found for the initial period of growth that the length of the plastic zone (l_p) was directly proportional to the current length of crack (l), that is, $l_p = Cl$; l_p and l were measured from the centre line of the specimen. I have shown[1] that C could be empirically related to the nominal stresses by the equation:

$$C = 1 + 0{\cdot}0013\sigma^3$$

where σ was the maximum tensile stress in the loading cycle. For the mild steel plate specimens used to determine the $\sigma^3 l = 5{\cdot}5$ relationship, it appears reasonable to assume a similar type of relationship, namely:

$$C = 1 + K\sigma^3$$

Estimates have been made of the length of the plastic zone developed ahead of a fatigue crack by applying a static tensile load to cracked fatigue specimens; high nominal stresses were imposed, so that measurable plastic zones resulted. An example is shown on Fig. 1. Taking measurements from the outside edge of the plate, that is, including the depth of the notch, $l_p = 0{\cdot}50$ in. and $l = 0{\cdot}28$ in.; thus $C = 1{\cdot}8$. The nominal stress applied was 13 tons/sq. in., giving $K = 0{\cdot}00036$. If λ is the length of plastic zone measured from the tip of the crack, then:

$$\lambda = l_p - l = 0{\cdot}00036\sigma^3 l$$

and substituting $\sigma^3 l = 5{\cdot}5$ will give the value of λ which must be subjected to stresses equal to or greater than the plain fatigue limit before the crack will grow; hence $\lambda = 5{\cdot}5 \times 0{\cdot}00036 = 0{\cdot}002$ in. This agrees with the value obtained by Isibasi and Uryu[4] from notched specimens.

Fatigue cracks in plain specimens are known to start on the surface, and metallographic examination

Fig. 1. Plastic zone at crack tip. Mild steel plate, $\frac{1}{8}$ in. thick by $2\frac{1}{4}$ in. wide, opposite edge notches 0·2 in. deep. Crack grown under cyclic stresses, then plate loaded statically. (× 3·9)

of the surface of polished plain fatigue specimens has shown that slip markings occur from which micro-cracks afterwards form. It is suggested that these will not grow into the body of the specimen (as opposed to spreading on the surface) until sufficient micro-cracks have joined together to form a crack of a critical minimum depth. Assuming the relationship $\sigma^2 l = 5{\cdot}5$ applies to these small crack-lengths (the smallest crack-length actually tested was 0·004 in.), then putting σ equal to a stress just greater than the plain fatigue limit ($\pm$ 13 tons/sq. in.), gives a value of crack-length 0·002 in. which must be formed as an entity, for it is implied that a shorter crack will not be propagated at this stress.

Thus, for mild steel, both the alternating stress required to initiate a crack in a notched specimen and that required to propagate a crack of given length can be correlated with the plain fatigue limit, if it is accepted that a crack of minimum depth 0·002 in. is formed at the plain fatigue limit.

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CHEMISTRY

Interaction of Picric Acid with Sodium Hydroxide in Water

In a previous paper[1], it was reported that a 360-mμ band of picric acid in water was found to shift to the red by about 35 mμ by addition of a concentrated solution of sodium hydroxide. Interaction of picric acid with sodium hydroxide in water has, therefore, been investigated by measurement of the absorption spectra of the picric acid solutions at various concentrations of sodium hydroxide. The results are shown in Fig. 1.

The absorption bands of the picric acid solution in the region 300–450 mμ in the absence of sodium

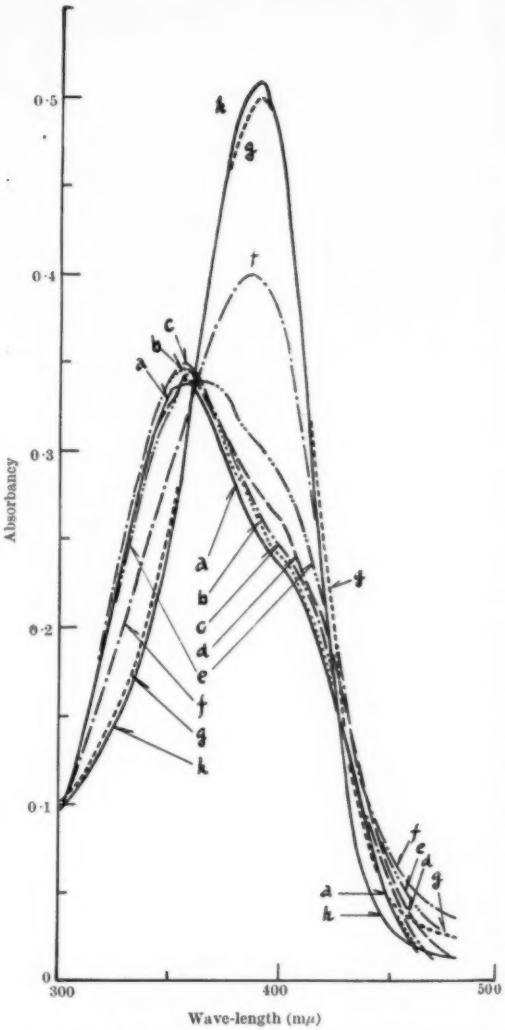
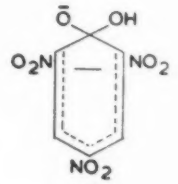


Fig. 1. Absorption spectra of aqueous solutions of picric acid ($2{\cdot}42 \times 10^{-5}$ *M*) at various concentrations of sodium hydroxide at 20° C. (path-length of cells, 1 cm.). Concentrations of sodium hydroxide: *a*, 0; *b*, 0·206 *N*; *c*, 0·411 *N*; *d*, 1·03 *N*; *e*, 1·44 *N*; *f*, 2·06 *N*; *g*, 3·09 *N*; *h*, 4·11 *N*

hydroxide is due mainly to picrate anion. The absorbancy of the 360-mμ band of picric acid slightly increases at low concentrations of sodium hydroxide up to 0·411 *N* and then decreases at concentrations of sodium hydroxide higher than 0·411 *N*. The increase in the absorbancy at 360 mμ can be interpreted as being due to nearly complete dissociation of picric acid, caused by sodium hydroxide. On the other hand, absorbancy at about 390 mμ increases with the increasing concentration of sodium hydroxide. The absorption curves of the solutions at the higher concentrations of sodium hydroxide over 2·06 *N*, showing the sharp and intense bands at about 390 mμ, are greatly different from those of the solutions with the low concentrations of sodium hydroxide. Accordingly, the intense 390-mμ band, the absorbancy of which decreases slowly when the

solution is stood at room temperature for long days, cannot be ascribed to picrate anion.

When 1,3,5-trinitrobenzene and its derivatives in water are treated with sodium hydroxide, red solutions are immediately formed. These red colours have been ascribed to complexes such as [trinitrobenzene·OH]⁻ (refs. 1 and 2). It has been reported by Kimura[3] that picric acid in a mixture of acetone and ethanol gives an intense 410-mμ band and a weak 485 mμ one when a drop of sodium hydroxide solution is added, owing to formation of [picric acid.CH_2-$COCH_3$]⁻. The intense 390 mμ band of picric acid in aqueous concentrated solution of sodium hydroxide may be expected to be due to a complex of [picrate anion·OH]⁻, which seems possibly to be the ion (I) of Meisenheimer's type[4].



(I)

The spectra were measured with a Hitachi *EPU*-2 spectrophotometer.

I wish to thank Prof. Y. Nomura for helpful discussions.

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Generation of Aerosols by Vapour-Phase Polymerization of Methyl Acrylate

THE particle generator made by us is the outgrowth of work by Melville[1], in which he studied the photopolymerization of methyl acrylate and methyl methacrylate vapour at low pressures in a closed chamber in which no other gas was present. On irradiation with ultra-violet light in the 2500-Å. region, a fairly dense cloud of particles is formed in the chamber. The ultra-violet light activates the monomer and small nuclei are formed, that is, a few molecules of polymer on which the remaining monomer gas can react. Once the reaction is initiated, it will continue without further irradiation.

We have found that this process can also be carried out in a flow system (Fig. 1) at atmospheric pressure so long as oxygen is excluded. Ordinary cylinder nitrogen gas was passed over freshly distilled monomer and mixed with a larger volume of nitrogen gas. It then entered a quartz tube of 3 cm. internal diameter where a beam of ultra-violet light was focused on it from a Hanovia type *A*, 500-W. high-pressure mercury arc lamp. The gas flowed past the light source at 0·1–0·5 cm./sec. Visible aerosols that exhibited higher-order Tyndall spectra were produced, indicating a fair degree of monodispersity. The methyl acrylate gave solid particles, while the methyl

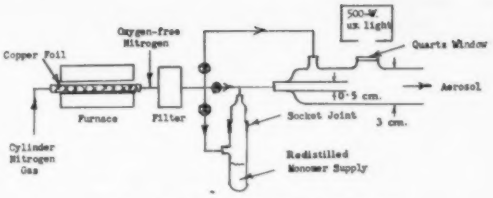

Fig. 1. Methyl acrylate particle generator

methacrylate produced liquid particles. Neither materials seemed to be stable in the electron microscope, but dark-field microscopy showed uniform particles ranging from 0·1 to 2·0μ, depending on the concentration of vapour and rate of flow.

The most difficult problem was the formation of polymer on the walls of the quartz tube, which prevented the short-wave radiation from reaching the monomer vapours. Some work was done with a vapour-free gas sheath to keep the polymer off the wall. However, due to the low rate of production of particles and the other problems mentioned above, the work was discontinued in favour of other devices for the production of homogeneous aerosols of submicron dimensions.

The work is presented here in the hope that it may stimulate others, who are not confronted by immediate practical needs, to follow up on this rather interesting variation on aerosol generators.

We acknowledge the guidance of Dr. S. Katz, who suggested this approach to the problem. The work was supported by the Air Force Cambridge Research Center, Bedford, Massachusetts (Contract No. *AF* 19(604)-2411), as part of a programme on electrostatic size classification of sub-micron aerosols.

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Determination of Nonanol Residues in Potatoes

A NEW method for the destruction of potato sprouts in the course of potato storage is ventilating with air containing nonanol in the amount of 0·1 mgm. per litre[1]. By applying this British method in our country we were very interested in the determination of nonanol in the ventilation air as well as in the potatoes after being treated in this way. The nonanol used is the branched isomer 3,5,5′-trimethylhexanol-1, produced by Imperial Chemical Industries, Ltd.

For the determination we use Feigl's spot test for the alcoholic hydroxyl group using the reagent vanadium oxinate[2] quantitatively, as has also been discussed by others[3–5]. We are applying this reaction using solid vanadium oxinate as reagent in a toluenic solution of nonanol.

The reagent vanadium oxinate is prepared by mixing a solution of 15 gm. 8-hydroxyquinoline in 600 ml. acetic acid (6 per cent) and a solution of 2·3 gm. sodium meta-vanadate ($NaVO_3.4H_2O$) in 600 ml. water. After 1 hr. the precipitate is filtered

by suction (*S.* and *S.* 595), first washed with water, then with a little acetone. The vanadium oxinate is dried *in vacuo* above silica.

Standard solutions are prepared in pure toluene and contains 0·2–3·0 mgm. nonanol per 7 ml. toluenic solution. For preparing the standardization curve, 7 ml. of such a solution and about 30 mgm. of the solid vanadium oxinate are mixed in a test tube (diam. 16 mm.) closed with a marble and immersed for 1 hr. in a boiling water bath. After this heating period the tube is cooled for 10 min. in cold streaming water. The orange-coloured reaction solution is filtered through a stiff piece of wadding, which is then washed out with 2 ml. pure toluene. The reaction solution and wash liquid together are made up to exactly 10 ml. A reaction blank is prepared by treating 7 ml. pure toluene in the same way. Relative to the reaction blank the extinction of the coloured reaction solution is measured, in our case, with a Beckman *B* spectrophotometer at 375 mμ.

A straight standardization curve is obtained, showing that 3 mgm. nonanol in the end volume of 10 ml. gives $E_{375} = 0·6$. For determining the nonanol content in the ventilation air, an air sample of about 5 l. is taken. In a simple way this can be done by filling 5 flasks of about 1 l. with the air in the storage cell. Always using the same 50 ml. pure toluene the air in the flasks is washed by active shaking. From the toluenic nonanol solution 7 ml. is treated in the same way as described heretofore. It is also desirable to make a determination in a comparable storage cell without nonanol addition, for it is possible that potatoes produce traces of alcohols that also react. For determining the nonanol residues in treated potatoes a sample of 1 kgm. is peeled. Tubers and peels are treated separately and both are suspended by mixing ('*M.S.E.*—Atomix') in a total volume of 2·5 l. The suspensions are steam-distilled in a Quickfit 5-l. reaction flask with splash head containing a steam inlet, and 300 ml. distillate is collected. The steam distillate is washed twice with 25 ml. pure toluene, the toluenic layers are collected and made up to exactly 50 ml. From the toluenic nonanol solution 7 ml. is treated in the same way as described heretofore. By applying this method it has to be realized that the potato always contains an alcoholic fraction that also shows Feigl's reaction. Therefore, the determination should also be made with a sample that is not treated with nonanol but is stored in the same way as the whole bulk. The difference between the alcoholic content (measured as nonanol) of the sample that is treated and the content of the non-treated sample gives the nonanol residue we are seeking for.

The recovery of the determination measured with a known amount of nonanol added to the potatoes in the mixer amounts to about 75 per cent.

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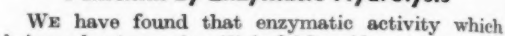
BIOCHEMISTRY

Formation of ε-Aminopenicillanic Acid from Penicillin by Enzymatic Hydrolysis

We have found that enzymatic activity which brings about reaction (1) is fairly widespread among micro-organisms :



penicillin

6-aminopenicillanic acid (I)

Sakaguchi and Murao[1], and later Murao[2], originally reported this type of enzyme activity to occur in *Penicillium chrysogenum* with penicillin *G* as substrate. Although we have been unable to confirm such activity in *P. chrysogenum* with penicillin *G* as substrate, with certain other penicillins, including penicillin *K*, such activity can be demonstrated.

Among the micro-organisms at least two distinct types of enzyme activity are encountered which bring about reaction (1). These differ primarily in the type of penicillins serving as substrate. One type is widely distributed among the actinomycetes and filamentous fungi and is also present in certain yeasts. With this type of enzyme, penicillin *K* and dihydro-*F* and also penicillin *V* are readily hydrolysed, but penicillin *G* is split only very slowly. Compared with penicillin *V*, penicillin *G* is only hydrolysed at about 1 per cent of the rate. Studies on this enzyme produced by a strain of *Streptomyces lavendulae* show that the activity is almost entirely extracellular with a *p*H optimum in the region of 9·0 and a temperature optimum of about 50° C. The enzyme can be precipitated with ammonium sulphate and dried as an acetone powder with little loss of activity. Enzyme formation does not appear to be induced by growing in the presence of the substrate.

The other type of activity has only been detected among the bacteria and appears to be largely confined to the genera *Escherichia* and *Alcaligenes*, but activity has also been detected in certain other genera. With any given species there is a high degree of strain specificity with regard to enzyme formation. With this type of enzyme, penicillin *G* is hydrolysed very readily, whereas penicillin *V* is only split at about 20 per cent of this rate. When penicillin *G* is used as substrate with cells of a strain of *Escherichia coli* which have been centrifuged and then resuspended at twice their original density, a concentration of 2 per cent penicillin *G* can be converted to 6-amino-penicillanic acid to 95 per cent of completion in 4 hr. Studies with a strain of *E. coli* show the *p*H optimum for this enzyme to be 7·5–8·5 with a temperature optimum of about 40° C. With the species of *Escherichia* the enzyme activity is usually associated with

the cells but with other bacteria considerable activity may occur extracellularly. As with the enzyme produced by the actinomycetes and moulds there is no evidence of induced enzyme formation.

In addition to the hydrolysis of penicillin to give 6-aminopenicillanic acid, this enzyme also facilitates the reaction in the opposite direction so as to bring about the synthesis of penicillin from 6-aminopenicillanic acid and a suitable side-chain. Using a strain of *E. coli* the optimum *p*H for penicillin *G* synthesis from 6-aminopenicillanic acid and phenylacetic acid is about 5·5, in contrast to an optimum of about 8·0 for hydrolysis. The synthetic reaction is also favoured, as might be expected, by increased concentration of 6-aminopenicillanic acid. Reaction in the direction of synthesis shows a similar specificity with regard to the type of penicillin as does the hydrolytic reaction.

We acknowledge our appreciation of valuable discussions with Dr. J. Ferquharson, director of research, and to the Board of Beecham Research Laboratories, Ltd., for permission to publish.

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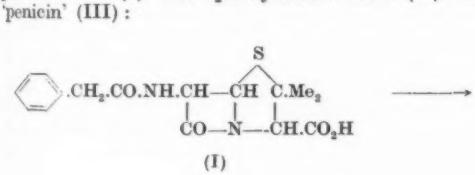
Bacterial Penicillin Amidase

Sakaguchi and Murao[1] reported on the presence of an enzyme in the mycelium of *Penicillium chrysogenum* and *Aspergillus oryzae* which would split penicillin *G* (I) into phenylacetic acid (II) and 'penicin' (III):



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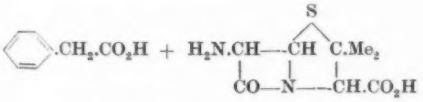

(II) (III)

Although they offered no rigorous proof of structure, they postulated that 'penicin' was the compound formed. In the nomenclature of Sheehan *et al.*[2], 'penicin' is termed 6-aminopenicillanic acid. We have attempted to reproduce the work, but have not been able to detect even small amounts of (III). Batchelor *et al.*[3] demonstrated the presence of (III) in penicillin fermentations which were carried out in the absence of added side-chain precursor. (III) was detected by activation of the fermentation liquor with phenylacetyl chloride after removal of the natural penicillins by solvent extraction at low *p*H. This resulted in the formation of (I), which could be measured by standard bacterial inhibition assays.

We wish to report upon the formation of (III) from (I) through the action of a penicillin amidase prepared from cells of *Alcaligenes faecalis*. A preliminary survey was first made of cultures in an attempt to demonstrate the presence of this amidase. Under the conditions used, traces of (III) were produced from (I) by cells of *Aerobacter cloacae*, *Bacillus subtilis* var. *niger*, *Micrococcus lysodeikticus*, and *Mycobacterium phlei*. Much greater amounts were detected when *A. faecalis* was used, and further work was concentrated upon this organism.

The standard amidase assay used consisted of growing the cells for 18 hr. at 27° C. on a rotary shaker, collecting cells by centrifuging 20·0 ml. of broth, and adding 0·5 ml. of an 80 mgm. per ml. solution of the potassium salt of (I) in 0·1 *M* *p*H 7·5 potassium phosphate buffer plus sufficient of the same buffer to bring the volume to 2·0 ml. The reaction mixture was incubated in a 37° C. water-bath with intermittent shaking for 4 hr. The supernatant was then assayed for (III) by treatment with phenylacetyl chloride[3] and bioassaying the (I) formed by a plate diffusion assay.

That (III) was the product formed was proved by its isolation in crystalline form from a large-scale reaction mixture. (III) was identified by comparison with the authentic compound using chemical and infra-red analyses.

The specificity of the enzyme was tested by comparison of activity using penicillins *G*, *K* and *V* and α-phenoxyethyl penicillin as substrates. The production of (III) was greatest from (I). To ensure that permeability barriers did not account for the specificity, a cell-free enzyme preparation was made and its specificity again tested. Cells of *A. faecalis* grown in Difco heart infusion broth were exposed for 30 min. in a 10 kc./s. Raytheon sonic oscillator. The debris was removed by centrifugation in the cold at 12,000*g* for 30 min. The activity of this cell-free extract was tested for production of (III) from the various penicillins (Table 1). It can be seen that the same order of activity is obtained with both preparations. The soluble preparation was not tested on α-phenoxyethyl penicillin.

The ability of the enzyme to catalyse the reverse reactions was tested by adding to a mixture of cells and (III), sodium phenylacetate, sodium phenoxyacetate, and sodium caproate. Measurable amounts of (I) and penicillin *K* but not of penicillin *V* were formed under the conditions of the experiment (Table 2). A similar experiment with α-phenoxypropionic acid and (III) failed to reveal any synthesis of α-phenoxyethyl penicillin. The specificity of the synthesis approximates that of the reverse reaction, indicating that the same enzyme is involved.

Almost complete conversion of (I) to (III) could be obtained at lower levels of (I) and longer incubation

Table 1. Specificity of *A. faecalis* Amidase for Different Substrates

Source of enzyme	Substrate			
	Penicillin *G*	Penicillin *V*	Penicillin *K*	α-Phenoxyethyl penicillin
Whole cells	5,740	1,015	3,045	294
Sonic extract	5,740	805	2,170	

Results expressed in μgm./ml. 6-aminopenicillanic acid.

Table 2. Specificity of Synthesis of Different Penicillins by *A. faecalis* Amidase

Substrates	Whole cells	Sonic extract
(III) + Sodium phenylacetate	444	91
(III) + Sodium phenoxyacetate	<10	<10
(III) + Sodium caproate	265	80

Substrate concentrations, 10 mgm./ml. Results expressed in units/ml. in terms of (I).

Table 3. Penicillin *G* Amidase Activity in Re-used *A. faecalis* Cells

Consecutive run No.	Reaction time (hr.)	μgm./ml. (III)
1	5½	2,675
2	18½	4,050
3	4½	3,280
4	18½	lost
5	4½	3,825

times than used in the standard assay system (5 mgm. per ml. final concentration of (I) for a 6-hr. incubation time).

The enzyme activity found in whole cell preparations was extremely stable. Cells have been re-used as much as five times. After centrifugation and further incubation with fresh (I), there was no apparent loss in (III) production (Table 3).

A more detailed account of these experiments will be published elsewhere.

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Production of Lysergic Acid Derivatives by a Strain of *Claviceps paspali* Stevens and Hall in Submerged Culture

A strain of *Claviceps paspali* Stevens and Hall isolated from the grass *Paspalum distichum* L. found growing on a hill in the neighbourhood of Rome was found, after propagation on a rye embryo grown on agar[1], to be capable of producing lysergic acid derivatives in submerged culture.

The culture medium used had the following composition: mannitol, 3 per cent; ammonium succinate, 3 per cent; potassium dihydrogen phosphate, 0·1 per cent; $MgSO_4.7H_2O$, 0·03 per cent; tap water (*p*H 5·2). Experiments were carried out in 500-ml. shake flasks containing 100 ml. of culture fluid and agitated on a rotary shaker, as well as in stirred fermenters up to 500 litres in capacity. The lysergic acid derivatives were almost completely released into the culture medium. Their production, followed colorimetrically by means of the van Urk reaction[2], began on the second day and increased until the ninth day, when concentrations up to 2 mgm. per ml. (calculated as lysergic acid) were reached. An excess of oxygen in the culture fluid was essential for production of alkaloid.

The bases were extracted from the filtered culture media at *p*H 7·2–7·4 with organic solvents and transferred to water (by extraction with diluted acids). The alkaloids were then concentrated by repeating this procedure several times, and finally recovered from the organic solvent phase as the free bases or the maleates.

Four main substances were obtained which were recognized as two pairs of isomers, deriving from lysergic and *iso*lysergic acid respectively.

The members of the first pair of isomers were both obtained in the crystalline state and identified as lysergic acid amide (*iso*ergine[3]) and *iso*lysergic acid amide (ergine[4]); their decomposition points, crystal form, chromatographic behaviour and infra-red spectra were identical with the corresponding properties of authentic specimens. On hydrolysis with *N* sodium hydroxide, lysergic acid amide gave ammonia and lysergic acid in good yield; the lysergic acid thus obtained was identical in all respects with an authentic specimen derived from natural ergot. The mixture of both pairs of alkaloids on hydrolysis with *N* sodium hydroxide gave ammonia and lysergic and *iso*lysergic acid, which were identified chromatographically. On treatment with anhydrous hydrazine or hydrazine hydrate[5], lysergic acid amide as well as *iso*lysergic acid amide gave racemic *iso*lysergic acid hydrazide in good yield; the latter was identified by its infra-red spectrum.

The members of the second pair of alkaloids yielded readily one molecule of acetaldehyde and one molecule of ammonia on treatment with diluted mineral acids in the boiling water-bath. The lysergic acid derivative was easily transformed into lysergic acid amide, with concomitant evolution of acetaldehyde, at *p*H 8 and 50°. The latter reaction occurs slowly even on standing at room temperature. The isomer derived from lysergic acid was obtained in the crystalline state as the free base from chloroform and as the acid maleate from methanol–ether. The free base was obtained in long solvent-free prisms which started to decompose at 135° C. (Kofler) and showed $[\alpha]_D^{20°} + 29° \pm 2°$ (C = 1 in dimethylformamide) and no appreciable rotation in pyridine. Its ultraviolet spectrum was identical with that of other amide-substituted derivatives of lysergic acid (maxima at 242 and 312 mμ). The infra-red spectrum is shown in Fig. 1.

Analysis (free base): calculated for $C_{16}H_{21}N_3O_2$ (311·37): C, 69·43; H, 6·80; N, 13·59. Found: C, 69·23; 69·30; H, 6·94–7·04; N, 13·69.

Analysis (maleate): calculated for $C_{16}H_{21}N_3O_2.C_4H_4O_4$ (427·44): C, 61·81; H, 5·90; N, 9·83. Found: C, 61·30; H, 6·33; N, 9·37.

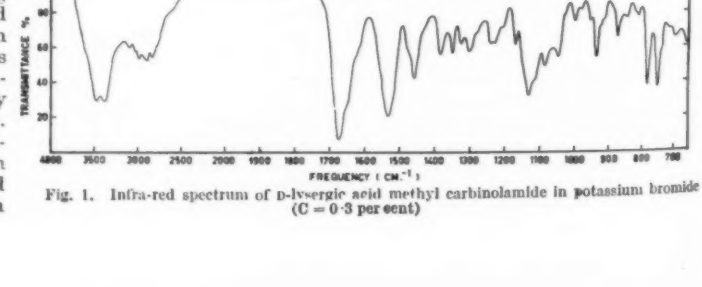

Fig. 1. Infra-red spectrum of D-lysergic acid methyl carbinolamide in potassium bromide (C = 0·3 per cent)

The second member of the pair of isomers, derived from *iso*lysergic acid, was not obtained in the crystalline form; but by isomerization with diluted acetic acid, it was readily transformed into the isomer obtained from lysergic acid described above.

The two lysergic acid derivatives yielding acetaldehyde are thought to have the acetaldehyde moiety linked to the lysergic acid moiety in the form of the carbinolamide linkage:

$$\begin{array}{c} CH_3 \\ | \\ -CONH.C.OH \\ | \\ H \end{array}$$

Neither the two isomers of lysergic acid amide nor those of lysergic acid methyl carbinolamide have previously been reported to occur in Nature.

Full details of this work will be published elsewhere.

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Microbial Synthesis of Protein in Relation to the Biogenesis of Nucleic Acids with *Azotobacter vinelandii* as the Test Organism

Caspersson[1] and Brachet[2] first directed attention to the possible role of ribonucleic acid in protein synthesis. This role has been re-evaluated by Brachet and Six[3]. Ribonucleic acid is supposed to serve as a template for protein synthesis. Evidence in favour of and against this hypothesis has been documented by Chantrenne[4], Meister[5], Simkin[6] and Hartman and Buchanan[7].

One of the most useful tools in demonstrating the relationship between protein and nucleic acid syntheses is to use antibiotics and antimetabolites which interfere with either one or both the processes[4–6]. The mechanism of incorporation of radioactive amino-acids into protein of particulate preparations of *Azotobacter vinelandii* is being investigated in detail in this laboratory. As a prelude to that work, the effect of some antibiotics and antimetabolites on the synthesis of nucleic acid and of protein in whole cells of *A. vinelandii* has been studied. Similar effects have been observed in cell-free preparations as well.

Disodium hydrogen phosphate (^{32}P) and sodium sulphate (^{35}S) were found to be rapidly incorporated into the growing cells of *A. vinelandii*. The fraction soluble in trichloracetic acid attained saturation with either tracer, phosphorus-32 or sulphur-35, within about an hour, whereas incorporation into the fractions insoluble in trichloracetic acid maintained a steady rate of incorporation in parallel with the growth of the cells. The resting cells of *A. vinelandii* similarly incorporated phosphorus-32 and sulphur-35 at a comparatively good rate. As in the case of growing cells, a source of energy, for example sucrose, was needed for the incorporation of both the tracers into the resting cells. Analyses of the fractions insoluble in trichloracetic acid showed that 90 per cent of the phosphorus-32 was incorporated into nucleic acids, whereas 97 per cent of the sulphur-35 was incorporated into protein. Thus the incorporation of phosphorus-32 and sulphur-35 into the fractions insoluble in trichloracetic acid of the resting cells can be looked upon as reflecting protein and nucleic acid syntheses respectively.

The results of inhibition studies of the incorporations of phosphorus-32 and sulphur-35 into resting cells of *A. vinelandii* in the presence of antibiotics and antimetabolites are presented in Table 1. The detailed kinetic results will be presented elsewhere. The concentrations of the inhibitors chosen are three times those required for inhibition of growth.

Table 1. Effect of Antibiotics and Antimetabolites on the Incorporation of Phosphorus-32 and Sulphur-35 into the Nucleic Acids and Protein of the Resting Cells of *A. vinelandii*

Antibiotic or antimetabolite used	Inhibition of incorporation (per cent)*	
	Phosphorus-32	Sulphur-35
Chloramphenicol (600 μgm./ml.)	9	90
Streptomycin (400 μgm./ml.)	45	90
Penicillin (114 μgm./ml.)	19	54
p-Fluorophenylalanine (720 μgm./ml.)	17	36
8-Azaguanine (600 μgm./ml.)	18	71

* Percentage inhibitions have been calculated with reference to the incorporation of the tracers into the fractions of the control insoluble in trichloracetic acid containing no antibiotic or antimetabolite, which was 400 counts/min. in the case of phosphorus-32 and 375 counts/min. in the case of sulphur-35.

In experiments on the incorporation of phosphorus-32, incubation was at 30° C. for 2 hr. with constant shaking in a total volume of 10 ml. containing 610 μmoles of sucrose, 42 μmoles of radioactive potassium phosphate, *p*H 7·0 ($2·4 \times 10^6$ counts/min.), 150 mgm. (on dry weight basis) of cells of *A. vinelandii* and a suitable amount of growth inhibitor or antimetabolite (see Table 1). For the incorporation of sulphur-35, conditions were exactly the same with the exception that 23 μmoles of radioactive sodium sulphate (2×10^6 counts/min.) were added instead of phosphate. Non-radioactive phosphate buffer (42 μmoles) was, however, included. Control incubations without any antibiotic or antimetabolite were always run. Incorporation was stopped by quick centrifugation at 20,000*g* followed by washings; the cells were washed four times, each time with 10 ml. of 0·05 *M* phosphate or 0·05 *M* sulphate respectively. Washed cells were treated with 1 ml. of cold 10 per cent trichloracetic acid for 30 min. The precipitate collected by centrifugation was re-treated with 1 ml. of cold 5 per cent trichloracetic acid. Finally, the precipitate was washed twice in each case with 10 ml. of 0·05 *M* phosphate (or sulphate) and suspended in 10 ml. of water. Aliquots were plated, dried and counted in a thin-window Geiger counter (Nuclear Chicago Co.). Since the plating was done at infinite thinness, no self-absorption correction was needed.

Incorporation of phosphorus-32 into nucleic acids is affected only to a small extent in the presence of chloramphenicol. Protein synthesis as reflected by incorporation of sulphur-35 is, however, inhibited to a great extent as expected. Streptomycin similarly interferes with incorporation of sulphur-35. Incorporation of phosphorus-32 is also inhibited to a considerable extent. Penicillin, which is known to

stop bacterial growth by interfering with the synthesis of cell walls, does not affect the synthesis of nucleic acid very much, whereas incorporation of sulphur-35 is inhibited to a considerable extent. The amino-acid analogue, *p*-fluorophenylalanine, inhibits synthesis of protein and of nucleic acid to small extents. In the case of the purine analogue, 8-azaguanine, incorporation of sulphur-35 is considerably inhibited, although there is only slight interference with the synthesis of nucleic acid. The abnormal nucleic acid produced by the incorporation of azaguanine, as in the case of other micro-organisms[8], may indicate failure to provide a template for the synthesis of normal protein.

Similarly, the rate of incorporation of ^{14}C-*l*-glutamate into protein of cell-free particulate preparations of *A. vinelandii* was found to be affected in the presence of some of the antibiotics and antimetabolites (Table 2). The particulate fraction sedimenting between 2,000 and 30,000*g* was prepared by fractional centrifugation of the cell-free extracts of *A. vinelandii*, made in a mechanical cell disintegrator. The preparation was repeatedly washed with phosphate buffer.

Table 2. Effect of Antibiotics and Antimetabolites on the Incorporation of ^{14}C-*l*-glutamate into Protein in Particulate Preparations of *A. vinelandii*

Antibiotic or antimetabolite added	Glutamate incorporated (mμ mole)/(mgm. protein in 2 hr.)	Inhibition (per cent)
None	7·5	—
Chloramphenicol (600 μgm./ml.)	0·7	90
Penicillin (160 μgm./ml.)	7·6	none
Streptomycin (400 μgm./ml.)	2·8	63
8-Azaguanine (305 μgm./ml.)	7·5	none
p-Fluorophenylalanine (365 μgm./ml.)	6·2	17

The control incubation mixture without any antibiotic or antimetabolite contained in a total volume of 2·14 ml. of 100 μmoles of potassium phosphate buffer, *p*H 7·0; 10 μmoles of magnesium chloride; 10 μmoles of adenosine triphosphate; 10 μmoles of hexose diphosphate; 1·4 μmoles of *l*-glutamate ($3{\cdot}40 \times 10^5$ counts/min./μmole) and particulate preparation equivalent to 2·2 mgm. protein. Incubation was at 34° C. for 2 hr. The reaction was stopped by the addition of 10 per cent trichloracetic acid. The precipitated protein was repeatedly washed with trichloracetic acid, thioglycolic acid and water and finally suspended in water. An aliquot of the suspension was plated, dried and counted in the gas-flow counter. Protein from the zero minute control gave only a few counts above background after similar treatment.

Chloramphenicol inhibits the incorporation of *l*-glutamic acid to the extent of 90 per cent, whereas penicillin does not affect it at all, indicating that the L-amino-acid is probably not incorporated into the cell-wall peptide[9]. The use of ^{14}C-*dl*-glutamate in similar circumstances leads to about 27 per cent inhibition in the presence of penicillin, indicating partial incorporation into cell-wall material. Inhibition in the presence of streptomycin is also considerable. As 8-azaguanine does not affect the incorporation of amino-acid at all, it can be assumed that there is no synthesis of nucleic acid and subsequent formation of abnormal nucleic acids[8] in the cell-free preparations, in sharp contrast to the observations made with the intact cells. Some inhibition observed with the amino-acid analogue may reflect its competitive inhibition with the ^{14}C-amino-acid during incorporation into protein, as a mixture of seventeen natural amino-acids has been found to inhibit the incorporation of glutamate to a considerable extent.

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Flavonoid Pigments of *Lathyrus odoratus*

Although the genetics and chemistry of flower colour variation in the garden sweet pea, *Lathyrus odoratus*, have been much investigated[1], none of the pigments present has yet been fully characterized. As part of a general study of flavonoid production in garden plants[2–4], these pigments have now been analysed by means of paper chromatography and absorption spectrophotometry. Since the sweet pea varieties used by earlier investigators were not available, comparable colour forms were chosen from the wide range of present-day varieties. Examination by chromatography divided them into three main classes, depending on whether their anthocyanins were derived from the orange pelargonidin, the magenta cyanidin or the mauve delphinidin. Three deeply pigmented varieties, 'Air Warden', 'Harrow' and 'Jupiter', representing respectively each of these colour classes, were chosen for detailed examination since they contained the greatest number of pigments.

Table 1. Occurrence of Flavonoids in Sweet Pea Colour Varieties

Variety	Anthocyanins	Flavonol glycosides
'Air Warden' scarlet cerise (also other varieties: orange and salmon shades)	pelargonidin 3-rhamnoside 5-glucoside-3-rhamnoside* 3-glucoside 3-xylosylglucoside 3 : 5-diglucoside	kampferol 3-rhamnoside*
'Harrow' deep carmine (also other varieties: pink and rose shades)	cyanidin and peonidin 3-rhamnoside 5-glucoside-3-rhamnoside* 3-glucoside 3-xylosylglucoside peonidin 3 : 5-diglucoside	kampferol and quercetin 3-rhamnoside*
'Jupiter' deep purple (also other varieties: lilac, mauve and blue shades)	delphinidin and petunidin 3-rhamnoside delphinidin, petunidin and malvidin 5-glucoside-3-rhamnoside*	kampferol, quercetin and myricetin 3-rhamnoside*

* Major glycosides; minor flavonol glycosides not shown.

Nineteen anthocyanins and three flavonol glycosides were isolated and identified by means of methods already described[2]. Their distribution is indicated in Table 1. Paler-coloured varieties generally contained the same pigments as the intensely coloured types though in less amount, except that the anthocyanidin 3-rhamnosides were completely lacking. Five white varieties which were examined contained the same flavonol glycosides as either 'Air Warden' or 'Harrow'; a myricetin-containing white form equivalent to 'Jupiter' was not found. Besides the three flavonol 3-rhamnosides shown in Table 1, several other flavonol glycosides were present in small amounts in most varieties. Three (that occurred with kampferol 3-rhamnoside in the white variety 'Valerie') were kampferol derivatives which had two or more sugar residues, of which one, at least, in each case was rhamnose. 'Valerie' also contained the cinnamic acid related to kampferol, namely, *p*-coumaric acid. It was present esterified both with glucose and with a rhamnosylglucose (probably rutinose). The glucose ester is the same compound that has recently been identified in potato berries[5] and flowers of *Primula obconica* (Corner, J. J., and Harborne, J. B., unpublished work); the other ester has not yet been described.

The presence in *Lathyrus* of two new series of anthocyanidin glycosides (that is, the 3-rhamnosides and 5-glucoside-3-rhamnosides) is noteworthy since the 3-substituted sugar, in almost all the known anthocyanins, is glucose. The new pigments have much higher R_F values than the corresponding glucosides in all the usual solvent systems. Furthermore, they are much more resistant than 3-glucosides and 3 : 5-diglucosides to hydrolysis by fungal anthocyanase (see ref. 6); the 5-glucoside-3-rhamnosides, for example, gave good yields of the corresponding 3-rhamnosides after incubation for 2 hr. with excess enzyme at 37° C. and *p*H 3·9.

Glycosides of all six common anthocyanidins are, with one exception, represented in both the new series: the exception is malvidin 3-rhamnoside which has, however, been provisionally identified on the basis of R_F values in wild *Lathyrus sativus*, following the observation (Pecket, R. C., private communication) that an unusual malvidin derivative was present in that species. Pecket found that other species of *Lathyrus* (including a wild *L. odoratus*) contained only 3-glucosides. The present discovery of as many as five different kinds of glycoside in the sweet-pea shows that domestication has had a very marked effect on pigment synthesis in this species. The only other plant known to contain anthocyanin mixtures as complex as these is *Streptocarpus* (which is of hybrid origin[4,7]).

In disagreement with an earlier report[1], related anthocyanidins and flavonols occur together in all the varieties examined. This agrees with findings in *Solanum phureja*[2] and a number of other plants[3,4]. The genes *E* and *Sm*, which control hydroxylation of the anthocyanidins in *Lathyrus*, evidently also determine the flavonol hydroxylation pattern. Since flavonols and anthocyanidins are both present as 3-rhamnosides, it is likely that the same enzyme controls the addition of this sugar to both kinds of pigment. The addition of the other sugar residues must, however, be controlled by enzymes which exhibit a greater degree of substrate specificity. These results thus provide additional evidence of the close biosynthetic relationship that exists between flavonols and the anthocyanidins and of the great complexity of pigment glycosidation that occurs in highly evolved garden plants.

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Ferricyanide Reduction Method for Reducing Sugars

The ferricyanide reduction method and its modifications[1-3] for the determination of reducing sugars are among the more commonly used techniques for this purpose. They depend on the spectrophotometric measurement of the amount of prussian blue formed when excess ferric iron is added to the reactant mixture.

As prussian blue forms an unstable, hydrophobic colloidal sol, protective agents, generally hydrophilic colloids, are added to keep it from flocculating. Gum ghatti[1,3], gum arabic[1], or 'Duponol'[2] is generally used. When added in excess they adsorb on the hydrophobic prussian blue, reversing the charge and stabilizing the sol.

However, the above-mentioned protective agents have several defects. The gums contain reducing materials which must first be oxidized with potassium permanganate; in addition, if the amount of glucose or other reducing sugar present in the aliquot is greater than 150–200 μgm., the resultant prussian blue frequently flocculates in spite of the protective agents, preventing accurate measurement. 'Duponol' thickens the reactant mixture, and great care must be taken to avoid the introduction of small air bubbles which tend to remain suspended.

Although oxalic acid has long been known to peptise prussian blue sols[4,5], its use does not seem to have been attempted in connexion with the ferricyanide method for reducing sugars. Its use is described in this communication.

The method followed was that of Folin and Malmros[1] as modified by Umbreit, Burris and Stauffer[3]. However, gum ghatti was omitted from the ferric iron solution. After heating the glucose–ferricyanide mixture in a boiling water bath for 15 min. and cooling, 5 ml. of ferric iron solution and then 1 ml. 0·8 per cent aqueous oxalic acid solution were added rapidly. The volume was made up to 25 ml. with distilled water, and after standing 15 min. the optical density at 520 mμ was measured with a Beckman *DU* spectrophotometer. A reagent blank was prepared and all determinations were in duplicate.

Fig. 1 indicates that Beer's law is obeyed up to 300 μgm. of glucose. The reactant solution appeared perfectly clear when observed with the unaided eye or a microscope, even after standing for 1–2 hr. When gum ghatti or gum arabic was used as a stabilizer, microscopic aggregates could be seen after 10–15 min., and frequently flocculation occurred rapidly. The use of one-fifth as much oxalic acid also resulted in flocculation after 15 min., while if more than 1 ml.

Fig. 1. Plot of optical density at 520 mμ versus micrograms of glucose in aliquot. The means of duplicate determinations are plotted

was used, the sol 'dissolved'[6] and a greenish-yellow rather than a blue colour resulted. Although oxalic acid itself is a reducing agent, under the conditions described its reaction-rate is slow, and the reagent blank adequately compensates for any slight reduction of ferricyanide.

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PHYSIOLOGY

Urinary Amino-Acid Pattern of Cats on Diets of Varying Protein Content

Qualitative changes in the urinary amino-acid pattern of four adult cats (2 males, 2 females) were investigated, while feeding them a series of mixed diets of progressively decreasing protein content in order to estimate the minimum dietary protein necessary to maintain nitrogen equilibrium[1].

Six diets were prepared in which the protein was provided by white fish and liver, and by varying the proportion of fish the following protein concentrations (on a dry-weight basis) were achieved: 46, 39, 32, 26, 19 and 13 per cent. The experiment was divided into six consecutive fortnightly periods: during the first of these each cat, which was caged separately, received the diet containing the greatest concentration of protein; during the second period the next greatest, and so on. Urine was collected from each cat on the last day of each period and analysed by two-dimensional ascending paper chromatography, the solvents being phenol/water (4 : 1) and 2.4.6 collidine/2.6 lutidine/water (1 : 1 : 1). Analysis was carried out on 15 μl. urine; a similar volume of an oxidized specimen was run at the same time. Papers were developed with ninhydrin and spots identified by the position to which they ran and their colour reaction with ninhydrin[2], and by running pure samples of amino-acids with the urine specimens in some instances.

Some 6–9 spots were usually detected, the three strongest and most consistent being methyl-histidine, taurine and felinine. Glycine and alanine were variably present; the other spots were unidentified. Methyl-histidine was present in each cat's urine on each diet. It has been suggested that it derives from ingested anserine[3] and has been identified in large quantities in the urine of several carnivores, including that of domestic cats[3]. Taurine disappeared from the urine of both male cats on the two lowest protein diets, when all the animals were in negative nitrogen balance[1], and from the urine of both females collected at the end of the period on the 13 per cent protein diet. After this period all the cats were placed on high-protein diets and taurine reappeared in all urine specimens. Felinine (cystein-S-*iso*pentanol)[4] was almost always present in the unoxidized specimens, often producing the strongest spot. It was never present after oxidation: if this was carried out by hydrogen peroxide in the presence of ammonium molybdate[2] a spot in the position normally occupied by cysteic acid invariably occurred; if by hydrogen peroxide alone a brownish spot appeared close to methyl-histidine (with an R_F value slightly less in phenol, slightly greater in collidine/lutidine). Datta and Harris[3] in no case found both felinine ('cat spot') and taurine occurring in quantity in the same urine, and suggested on the results of dietary experiments that felinine is synthesized in the body from cysteine which would otherwise be further metabolized to taurine, this synthesis being encouraged by some component of cod-liver oil. However, it is shown in the experiment reported here that both taurine and felinine may be excreted in considerable quantity at the same time, but that on diets providing less than the minimum concentration of protein necessary to maintain nitrogen equilibrium (21 per cent dry weight in this experiment[1]) felinine may be excreted preferentially to taurine. It has been suggested[5] that felinine may be formed in the cat kidney (where it may exist in a bound form) and be excreted directly; only traces were detected in plasma and bladder tissue, and none in kidney, liver, brain or gastrocnemius, whereas in cat urine its concentration was estimated as 185 mgm. per cent[5]. Recently, leucine labelled with carbon-14 and mevalonic acid have been shown to participate in felinine biosynthesis in the cat[6].

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Restoration of Membrane Excitability of Calcium-deficient Muscles by Anodal Polarization

It is well known that marked electrophysiological and biochemical disturbances occur in nerve and muscle immersed in calcium-free Ringer's solution[1]. In the present experiment, isolated frog (*Rana pipiens*) sartorius muscles were used. When they were soaked in calcium-free Ringer solution (112 m*M* sodium chloride ; 2 m*M* potassium chloride ; 2·4 m*M* sodium bicarbonate), initial hyper-excitability was followed by a loss of excitability. This effect of calcium deficiency was enhanced by adding ethylenediaminetetraacetic acid to the medium. In calcium-free Ringer containing 4 m*M* ethylenediaminetetraacetic acid, muscles twitch while the resting potential rapidly drops to 50–30 mV. within an hour. As usual, the electrical activity which ordinarily accompanies stimulation was completely but reversibly eliminated in the 60–120 min. following immersion. This loss of excitability cannot be explained simply by the reduction of the resting potential, since a number of fibres showed, transiently, a relatively high resting potential in spite of a loss of excitability[2]. Whether excitability was maintained depended on the susceptibility of individual fibres ; even a seasonal variation being apparent. For example, the electrical activity of some muscles disappeared instantaneously in calcium-free Ringer, particularly in spring frogs. This seems to suggest that excitability depends on the properties of the membrane *per se*, which may be altered by the presence or absence of calcium ions.

This concept was supported by the following experimental results on muscle fibres registering complete loss of excitability and reduced resting potential (40–20 mV.) in calcium-free Ringer solution (with or without ethylenediaminetetraacetic acid). In these fibres, it was possible to restore the electrical excitability by applying anodal polarization to the membrane, as Fig. 1 shows. Here, one microelectrode in a muscle fibre recorded the membrane potential, and another microelectrode in the same fibre passed both polarizing and stimulating currents. Repetitive anodal square pulses initiated 'break responses' above a critical level of hyperpolarization (record 3). If cathodal stimulations were applied during the passage of these anodal pulses, the action potentials were induced at a certain threshold level (record 2). The spike had higher magnitude during continuous anodal polarization (record 2). A certain magnitude of hyperpolarization and a certain period of passage of the current were necessary for production of action potentials.

In calcium-free Ringer solution, muscle apparently gains sodium and loses potassium (Miyamoto and Koketsu, unpublished observation). Neither reduction of intracellular potassium nor accumulation of potassium in the interfibre space seems to be directly responsible for reducing resting potential and excitability. As a matter of fact, in the present experiments, washing with calcium-free Ringer solution did not restore excitability.

The experiment described here clearly demonstrates that calcium ions in the external solution are not immediately necessary for the production of action potentials (for the opposite conclusion see ref. 3). So far as membrane property was maintained in the excitable state by applying anodal polarization, the membrane was capable of producing action potentials without external calcium. Thus, the loss of electrical activity of the membrane in calcium-free Ringer solution cannot be explained simply by the absence of external calcium ions. Presumably, changes in the physico-chemical property of the membrane resulting from withdrawal of the external calcium are responsible for the loss of membrane excitability. We found a serious disturbance in the metabolic energy supply (Abood and Koketsu, unpublished work) and also in the distribution of sodium, potassium, calcium, and magnesium ions (Miyamoto and Koketsu, unpublished work) when sartorius muscles were soaked in calcium-free Ringer solution with or without ethylenediamine tetraacetic acid.

An important problem is to determine whether these biochemical and biophysical disturbances are responsible for the loss of excitability. We may assume that short-lived anodal currents do not affect such

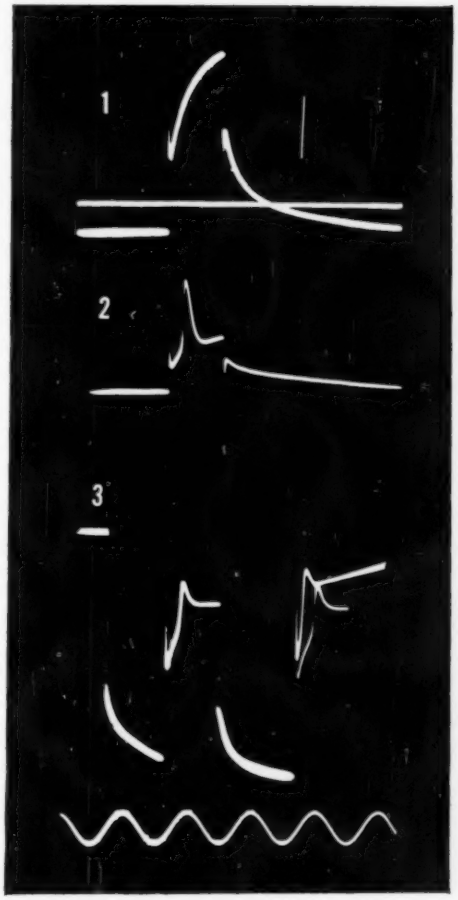

Fig. 1. Restoration of action potentials by anodal polarization of depolarized membrane in calcium-free Ringer solution. All records were obtained from the same muscle fibre, which gave no responses even to strong cathodal stimulation while resting potential was strongly depolarized (record 1, interval of two beams shows value of resting potential). Record 2 is action potential produced by cathodal stimulation when membrane potential was raised to about 100 mV. by continuous anodal polarization. Record 3 shows 'break responses' produced by anodal pulses, and also responses produced by cathodal pulses during passage of anodal pulses. Records 1 and 2 are single sweeps, and in record 3 three traces were superimposed with a time interval of 10/sec. Vertical line is 50 mV., and time mark is 100 cycles/sec.

events; and therefore, we conclude that they are not directly responsible for the loss of membrane excitability, even though they may be linked to the integrity of the membrane. The changes demonstrated in membrane properties can probably be explained by changes in molecular structure of the membrane, where anodal polarization appears to have an effect similar to calcium ions. Indeed, in calcium-free solution, bound membrane calcium seems to leak out (Miyamoto and Koketsu, unpublished work), probably disordering the molecular structure of the membrane. The normal molecular arrangement may be reconstructed either by adding calcium to the medium or by applying anodal currents through the membrane.

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Parallel Distribution of Calcium and Citric Acid in the Oviduct of the Hen

During the course of a recent investigation[1] it was found that there was a substantial fall in the plasma citric acid of pullets associated with the onset of reproductive activity. The mean plasma citric acid-level of immature pullets was 8·2 mgm./100 ml. compared with 2·8 mgm./100 ml. in laying birds.

The present experiment was designed to find out if this fall in blood citric acid was accompanied by changes in the citric acid content of other tisues. Citric acid was determined on trichloracetic acid extracts of the major tissues and organs from 5 immature pullets (3 months of age) and from 6 laying hens[2]. With the exception of the oviduct, the citric acid content of the tissues from the two groups of birds was very similar and agreed well with the results reported by Buffa and Peters[3] for the pigeon. Certain sections of the oviducts of laying birds, in particular the isthmus and to a lesser extent the uterus, were found to contain very high concentrations of citric acid, and more detailed studies were therefore made on this organ.

The oviducts were removed from the birds as quickly as possible after death and cooled rapidly. The magnum was divided transversely into 6, the isthmus into 7 and the uterus into 6 segments. Each segment, together with the infundibulum and vagina, was then divided in half longitudinally, one half being used for the determination of citric acid and the other half for ashing (800° C.) prior to analysis for calcium and magnesium. These metals were determined on acid extracts of the ash by photometric titration with 0·001 *N* ethylenediaminetetraacetic acid after removal of phosphate with an ion-exchange resin[4]. Murexide was used as indicator for the calcium titration (*p*H 12–13) and Eriochrome Black for the calcium plus magnesium titration (*p*H 10·0–10·5)[5].

Fig. 1 shows the mean calcium, magnesium and citric acid contents of the various sections of the oviducts of 5 hens. The magnum showed little variation in composition throughout its length, and single figures for the whole of this region are recorded. The most remarkable feature of this graph is the close relationship between the calcium and citric acid in the different sections of the isthmus and uterus. It is well known that tissues such as bone and dentine and secretions such as milk and seminal plasma are rich in both calcium and citric acid, but so far as we are aware, the extremely close parallel between these two cell constituents which we have observed in the hen's oviduct has not been reported in other tissues. The correlation coefficient, *r*, between calcium and citric acid for the 65 sections of the isthmus and uterus of the 5 hens was found to be + 0·97. The regression equation calculated from these data is:

$$y = 0{\cdot}237x + 17{\cdot}7$$

where y = mgm.calcium./100 gm., x = mgm. citric acid/100 gm.

From this equation it may be calculated that for each m.mole increase in citric acid there is an increase of 1·14 m.mole calcium.

The physiological significance of the extremely high level of citric acid in the isthmus is quite obscure. This region is about 10 cm. long and the distal half contains at least 300 mgm. citric acid/100 gm. fresh tissue. It is in this section of the oviduct that the shell membranes are laid down, but so far as is known, shell calcification does not occur until the uterus, which contains very much less calcium and citric acid, is reached.

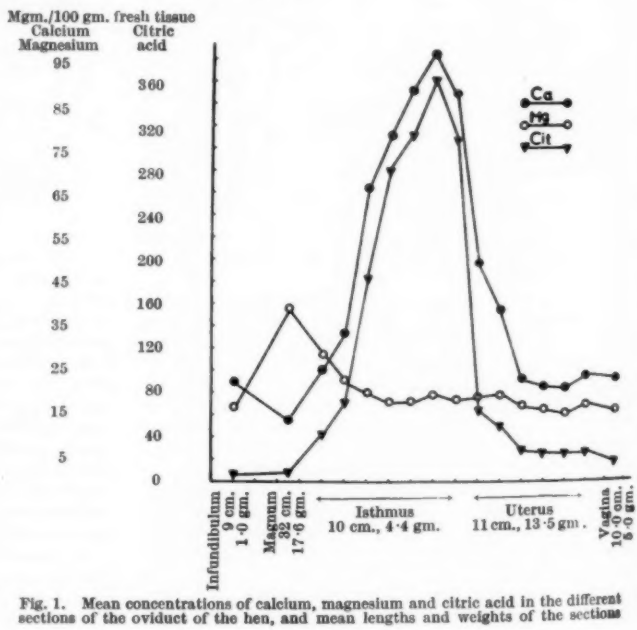

Fig. 1. Mean concentrations of calcium, magnesium and citric acid in the different sections of the oviduct of the hen, and mean lengths and weights of the sections

We have found that the concentration of citric acid in the isthmus is not altered in birds injected with fluoroacetate, and the enzymes of the Krebs cycle which seem most likely to be implicated in the high citric acid content of this region are under investigation.

The tubular region of the uterus adjacent to the isthmus, the isthmo-uterine junction[6], is considerably richer in calcium and citric acid than the thick muscular region where the main process of shell calcification occurs, and this may be due to the fact that the transition from isthmus to uterus is gradual, there being no definite histological boundary between the two regions[7].

Magnesium forms a complex ion with citrate[8] similar to that formed between calcium and citrate; but in spite of the large variations in citric acid in the different segments, the magnesium content of the isthmus and uterus is constant at a level of 15–20 mgm./100 gm. The magnum, however, which is relatively low in citric acid (less than 10 mgm./100 gm.) contains approximately twice as much magnesium (38 mgm./100 gm.) as any other region of the oviduct.

We wish to thank Dr. B. C. Saunders for a generous gift of sodium fluoroacetate.

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Oxytocin in the Neurohypophysis of the Laying Hen

Although it has been well known that the administration of posterior lobe hormones induces premature oviposition in the hen, *Gallus domesticus*[1,2], as in other fowls[3], it remains undetermined whether the hormone(s) plays an essential part in normal oviposition. The results presented here may throw light on the mechanism of oviposition in the domestic fowl.

Twenty-five White Leghorn hens in their first year of production were killed at the following times: (1) 3–4 hr. before expected oviposition; (2) within an hour before expected oviposition; (3) within 5 min. after oviposition; (4) 1–2 hr. after oviposition; (5) 5–6 hr. after oviposition. The posterior lobes of the hypophysis of each bird were extracted with 0·25 per cent acetic acid immediately after removal, and assayed for oxytocic activity against 'Pitocin' (Parke, Davis and Co.) on the isolated uterus of an oestrous virgin rat of Wistar strain, following Holton's method[4]. Dibenamine and atropine were added to the organ-bath.

Fig. 1 shows the mean hormone content per lobe and its 95 per cent fiducial limits. The differences between the lobes removed within 5 min. after oviposition and those removed at other times were

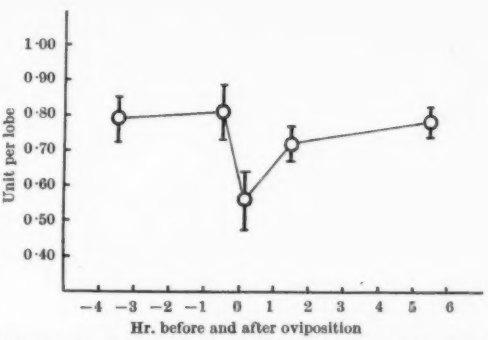

Fig. 1. Oxytocic hormone content in the posterior lobe of the hypophysis before and after oviposition. Each circle represents the mean value of determinations made on five hens. The vertical lines represent the fiducial limits of the mean (degree of confidence, 0·95)

significant ($P < 0·01$). These differences were not materially affected by using other criteria of comparison; for example, hormone content per milligram neurohypophysial tissue. No significant difference was found between the weights of the posterior lobes.

It would appear then that oviposition in the hen follows depletion of oxytocic hormone from the posterior lobe, and that the hormone accumulates in the hypophysis soon after oviposition.

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Hunger Reduction produced by Injecting Glucose into the Lateral Ventricle of the Rat

It has been repeatedly shown that the ventromedial nucleus of the hypothalamus is responsible for the satiation of hunger. According to Mayer[1], this is brought about by hypothalamic glucoreceptors. Because of the rapid removal of injected glucose from the blood-stream, direct experimental tests of Mayer's hypothesis have yielded conflicting results.

The technique of intraventricular injection employed in the present experiment is a modification of that developed by Feldberg and Sherwood[2] for use on cats, and details will be published elsewhere. In brief, a stainless steel cannula is stereotaxically implanted and permanently fixed in the lateral ventricle, and the animal is allowed to recover from the anæsthetic. Correct positioning is checked by injecting the satiated rat with a small quantity of 2 per cent saline through the cannula. If the cannula tip is in the ventricular system, the injected fluid reaches the hypothalamic osmoreceptors and the animal responds by drinking water. The validity of this test has been confirmed at autopsy by injecting a dye through the cannula.

The unrestrained animals are injected with an electrically driven micrometer syringe connected to the cannula by polythene tubing at a rate of 0·005 ml./min., to a total volume of 0·2 ml./kgm. body-weight. Such injections *per se* do not appear to

disturb the animals in any way. When not in use the cannulas are sealed off with sterile plastic bungs.

Four male hooded rats weighing between 225 and 325 gm. were arranged to receive 8 injections each, ordered according to a counterbalanced Latin square design, each animal serving as its own control. During the course of the experiment one rat dislodged its cannula and had to be killed. The results presented have been derived from the remaining three animals.

One of four different sterile solutions was administered at each injection, with an interval of at least 48 hr. between injections. The solutions so tested were : (*a*) 5 per cent dextrose, (*b*) 5 per cent fructose B.P.C., (*c*) 5 per cent dextrose containing 0·5 unit insulin per gram dextrose, and (*d*) a similar concentration of insulin in Locke's solution. These solutions are all approximately isotonic with rat cerebrospinal fluid.

Each injection lasted between 8 and 13 min. and commenced at the beginning of a ½-hr. test meal, when the animal was hungry for 19 hr. At the end of the test meal the food remaining in the cage was weighed to the nearest 0·5 gm., and the rat was allowed to eat for a further 4½ hr. Test meals on intermediate days served as no-injection controls. Water was freely available throughout.

Table 1. Grams of Food Eaten during Half-Hour Test Meals

Rat	No injection*	Fructose	Insulin	Glucose	Glucose-insulin
A	5·72	6·5 (3)	4·5 (2)	3·5 (4)	5·0 (1)
	$\sigma = 0{\cdot}48$	6·5 (6)	6·0 (7)	3·5 (5)	4·0 (8)
B	6·33	7·0 (1)	6·5 (4)	5·5 (3)	4·5 (2)
	$\sigma = 0{\cdot}91$	6·0 (8)	7·0 (5)	4·5 (6)	4·0 (7)
C	5·22	4·5 (4)	6·0 (1)	2·5 (2)	2·0 (3)
	$\sigma = 0{\cdot}95$	6·5 (5)	3·5 (8)	4·0 (7)	5·0 (6)

* Each no injection measure is the mean of nine readings. Figures in parentheses indicate the order of injection.

The results are shown in Table 1. Neither insulin alone nor fructose was found to depress intake. Both glucose and the glucose–insulin mixture reduced intake, as compared to fructose, by an average of approximately 35 per cent, and the reductions are both highly significant ($t = 8{\cdot}0$ and $10{\cdot}3$; $P < 0{\cdot}001$), but the difference between the extent of these reductions is not significant.

Since both glucose and fructose are readily metabolized by central nervous system tissue[2], their different effects on hunger imply either a selective receptor sensitivity or that fructose, unlike glucose, failed to reach the receptors. The latter would follow if the receptors are located on the blood side of the blood-brain barrier, which is permeable to glucose but not to fructose[3].

I wish to thank Prof. R. C. Oldfield for laboratory facilities and the Medical Research Council for providing funds for a stereotaxic instrument. The experiments were carried out during tenure of the Kenneth Craik Research Award of St. John's College, Cambridge.

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Excitation at the Crayfish Neuromuscular Junction with Decreased Membrane Conductance

The generally accepted mechanism of chemical transmission at excitatory and inhibitory synapses is an interaction of a transmitter substance with the sub-synaptic cell region, causing an increase of membrane conductance for specific ions. Excitatory transmission is essentially a depolarization due to the increased membrane permeability to one or more ions (predominantly Na^+) which have their effective 'electrochemical equilibrium' potential near zero membrane potential. This system has been worked out most thoroughly in the vertebrate nerve–muscle junction by Katz, Fatt and Del Castillo[1]. An interesting variation of the above postsynaptic mechanism is described here.

In a 'slow' crayfish muscle, stimulation of the motor axon at 75/sec. causes excitatory junctional potentials which facilitate and sum, building up to a plateau. The conductance of the membrane was determined by passing a short constant hyperpolarizing current pulse across the membrane of the fibre and measuring the resulting change in electrotonic potential. This was done at rest (lower trace, Fig. 1*A*) and during the plateau phase (upper trace). The electrotonic potential during excitation is decreased, showing the increase in conductance which is expected from analogy with other synapses. If the same experiment is repeated with the Ca^{++} level raised to four times normal (56 m*M*/l.) in the external medium the resting conductance is only little altered (less than 5 per cent), as seen in Fig. 1*B*. During the excitatory junctional potential plateau, however, with a somewhat smaller depolarization than in Fig. 1*A*, the applied current pulse results in an electrotonic potential which is more than 150 per cent of the control in the resting fibre. The membrane conductance, therefore, must have greatly decreased during excitatory transmission.

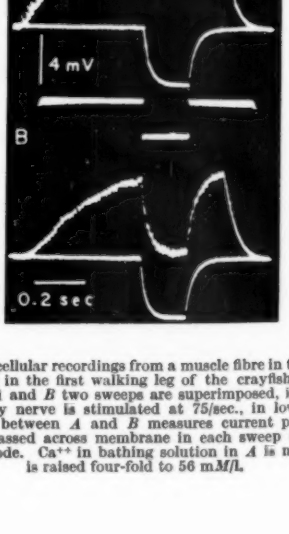

Fig. 1. Intracellular recordings from a muscle fibre in the abductor of the dactyl in the first walking leg of the crayfish (*Orconectes virilis*). In *A* and *B* two sweeps are superimposed, in the upper the excitatory nerve is stimulated at 75/sec., in lower fibre at rest. Trace between *A* and *B* measures current pulse ($2{\cdot}5 \times 10^{-6}$ amp.) passed across membrane in each sweep through the second electrode. Ca^{++} in bathing solution in *A* is normal, in *B* is raised four-fold to 56 m*M*/l.

The following interpretation is offered: During an excess of Ca^{++} the observed conductance decrease is due to the decreased permeability to ions with an equilibrium potential near the resting potential, or more negative than the resting potential. K^+ and/or Cl^- are the only known ions which fulfil this requirement.

It is thought that Ca^{++} excess does not cause the observed conductance decrease, but merely unmasks it by reducing the larger increase in sodium permeability which normally swamps and obscures the conductance decrease of K^+ and/or Cl^-. In support of this thesis it was seen that the normal excitatory junctional potential actually does not behave as if it were due to a conductance increase to an ion (or ions) with an 'equilibrium potential' near zero. We have found that during hyperpolarization of the resting membrane the excitatory junctional potential does not increase proportionally, as expected if it were purely of the conductance increase type. This had also been observed earlier[2], but the deviation from the predicted curve was attributed to a conductance increase caused by the hyperpolarizing current itself. Such an interpretation seems excluded in the present experiments. Furthermore, in the presence of Ca^{++} excess the excitatory junctional potential may actually decrease during hyperpolarization. Under these conditions one may even expect a reversal of the excitatory junctional potential at large negative resting potentials. This, however, could not be demonstrated experimentally even when the membrane potential was increased from -80 to -180 mV.

The following events are thus thought to occur at crustacean junctions: The excitatory transmitter combines with receptor sites at the junctional areas causing simultaneously two types of permeability changes. (1) An *increase* in membrane conductance predominantly to Na^+. (2) A *decrease* in conductance to K^+ and/or Cl^-. Both permeability changes cause depolarization and thus their effects are additive.

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A Second Mechanism of Inhibition at the Crayfish Neuromuscular Junction

IN crayfish muscle fibres single stimulation of an inhibitory axon sets up small inhibitory junctional potentials (Fig. 1*A*). Fatt and Katz[1] showed that such inhibitory potential changes are caused by an increase of the membrane conductance to ions (K^+ and/or Cl^-) with an 'electrochemical equilibrium' close to the resting potential. This equilibrium potential can readily be determined. For example, in the experiment of Fig. 1*E* short trains of depolarizing inhibitory potentials were repeated every 2 sec. Beginning at the arrow, the membrane was depolarized progressively by passing a current across it. The inhibitory potentials became smaller and eventually reversed their polarity at the equilibrium-level. A basically similar mechanism has been found

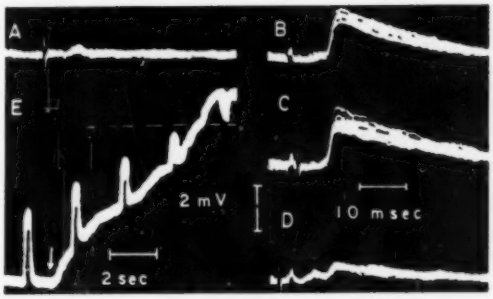

Fig. 1. Potentials recorded during one insertion of an intracellular electrode from a crayfish muscle fibre (abductor of the dactyl in the first walking leg of *Orconectes virilis*). Resting potential 80 mV. *A* to *D*. Single stimuli repeated 5/sec., several sweeps superimposed. *A*, inhibitory junctional potential. *B*, excitatory junctional potential. *C*, inhibitory plus excitatory potential, inhibitory stimulus 1 msec. after excitatory stimulus. *D*, inhibitory plus excitatory potential, inhibitory stimulus 3 msec. before excitatory stimulus. Time calibration 10 msec. for *A* to *D*. *E*, trains of inhibitory stimuli at 150/sec. repeated every 2 sec. At arrow start of membrane depolarization by passing current through second electrode. Broken line at 6 mV. depolarization indicates equilibrium potential of inhibition. Time calibration 2 sec. for *E*, voltage calibration 2 mV. for *A* to *E*

in all inhibitory synapses studied so far, for example, in motoneurons, the atrium of the heart and in stretch receptor neurons of the crayfish[3]. Here an additional mechanism is reported.

In the experiment of Fig. 1 the resting potential is about 6 mV. more negative than the inhibitory reversal potential, as shown in Fig. 1*E*. The size of the excitatory junctional potential in Fig. 1*B* is less than 3 mV., that is to say, it does not reach the inhibitory reversal potential. If now the conductance increase mechanism described above is the only mediator of inhibition, in this experimental situation the inhibitory potential should add to the excitatory potential and not reduce it. This, in fact, is the case in Fig. 1*C* where the timing is set so that the inhibitory potential (cf. Fig. 1*A*) falls on the peak of the excitatory one (Fig. 1*B*). However, if in Fig. 1*D* the inhibitory potential precedes the excitatory by 3 msec., the excitatory potential is greatly reduced in size. The timing is quite critical (cf. also ref. 3); in this experiment the effect is maximal for an interval 2–3 msec. Such an inhibitory effect cannot be explained by the increase of conductance mechanism, and therefore in addition a second mechanism of inhibition has to be postulated. This could be either a postsynaptic interaction between the inhibitory and excitatory transmitter substances, for example, in a competitive manner[1], or the inhibitor could influence the presynaptic excitatory nerve.

There is no direct method of studying the presynaptic nerve endings, but indirectly the state of excitatory facilitation and the frequency of spontaneous miniature potentials reveal presynaptic conditions. During the first second after a conditioning period of excitatory stimulation at high frequencies a burst of spontaneous miniature potentials is recorded in the muscle fibre[4], and for several seconds the size of single excitatory potentials is greatly increased as the result of presynaptic facilitation. This post-excitatory facilitation as well as the increase of frequency of miniature potentials is reduced if during the conditioning period inhibitory stimuli precede the excitatory ones by 2–3 msec. (as in Fig. 1*D*). If, however, the excitatory and inhibitory impulses are more separated no effect on post-

excitatory facilitation or miniatures is seen. Since post-excitatory facilitation and miniature frequency are selectively affected by the second mechanism of inhibition a presynaptic action on excitatory nerve endings is strongly indicated.

The presynaptic inhibition could be mediated by the transmitter agent released by the inhibitory nerve or by some electrical inhibition exerted on the excitatory nerve by the action potential in the inhibitory axon. We find that the essential features of the presynaptic inhibition can be imitated by applied γ-aminobutyric acid. This and some related compounds have, in all details so far studied, the same actions as the inhibitory transmitter substance; particularly their effect has the same equilibrium potential. If in a situation similar to Fig. 2 γ-aminobutyric acid is applied instead of stimulating the inhibitory nerve, the excitatory potential is decreased as in Fig. 1*D*. Thus, γ-aminobutyric acid also seems to inhibit the presynaptic excitatory axon in addition to its effect of increasing the conductance of the muscle membrane.

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HISTOCHEMISTRY

A Simple Azo-Dye Method for Histochemical Demonstration of Acid Phosphatase

A new diazonium salt, 'hexazonium pararosanilin', introduced for simultaneous azocoupling methods by Davis and Ornstein[1], was successfully employed in the demonstration of esterases at microscopic and electron-microscopic levels[2,3]. It was found that a method using α-naphthyl phosphate and hexazonium pararosanilin as coupler gives far better localization of acid phosphatase than any other method[4] using the same substrate, and the results seem to be not inferior to techniques using 'Naphthol *AS*'[5] or indoxyl phosphates[6]. The advantages of this method, besides the very good localization, are that α-naphthyl phosphate is water-soluble; it is more readily hydrolysed than the phosphate esters of 'Naphthol *AS*' or indoxyl derivatives, the reagents are commercially available, and the method works easily.

Best results are achieved with formalin-fixed frozen sections. Fixation for 24 hr. in 10 per cent formalin containing 1 per cent calcium chloride (*p*H adjusted to 7·0 with sodium hydroxide) is recommended. A longer fixation period (48–72 hr.) may be used, but results in a small decrease in activity. Fresh material is preferable, but autopsy material of 24 hr. gives fairly good results[7].

Frozen sections mounted in albuminized slides are dried at room temperature for 1–2 hr. They are incubated for 5–30 min. (depending on the tissue examined) at room temperature, rinsed in water, dehydrated in ethanol, cleared in xylol and mounted in balsam or synthetic medium. (After rinsing with distilled water a light blue nuclear staining, for example Weigert hæmatoxylin, may be used. This, however, will somewhat reduce the brightness of the histochemical staining.)

The incubating medium is prepared as follows:

To 20 mgm. of sodium α-acid phosphate (Dajac Lab., Philadelphia), dissolved in 13 ml. distilled water +5 ml. of Michaelis veronal–acetate buffer stock solution (9·714 gm. sodium acetate $3H_2O$ + 14·714 gm. sodium barbiturate in distilled water free from carbon dioxide, made up to 500 ml.), 1·6 ml. of 'hexazonium salt' solution is added. The hexazonium salt solution is prepared freshly by mixing in a test tube equal amounts (0·8 ml.) of these two stock solutions: (*a*) 4 per cent pararosanilin hydrochloride (*C.I.* 676, National Aniline Division, Allied Chemical and Dye Corporation, New York) in 2 *N* hydrochloric acid, and (*b*) 4 per cent sodium nitrite[8]. The *p*H of the medium is then adjusted by *p*H-meter to 6·5 with 1 *N* sodium hydroxide (about 0·6 ml.). After this the solution is filtered into a Coplin jar and is ready for incubation. The veronal–acetate buffer can be replaced by phosphate or *tris*-maleate buffers.

It is assumed that the diazotization of *p*-rosaniline (triphenylaminomethane) results in the formation of hexazonium salt[1] capable of forming dyes with one, two or eventually three azo groups. The assumption that different compounds are formed is supported by the observation that the colour of azo dye varies with the *p*H. The colour is reddish in acid *p*H, becoming brownish towards neutral *p*H. Further treatment with naphthols results in changes in colour of both the reaction product and of the background staining, suggesting the presence of free diazo groups in the azo dye formed. These free diazo groups, able to form complexes with proteins, may in this way contribute to the insolubility of the azo dye, thus improving the localization. The fresh hexazonium salt is stable enough at acid *p*H to permit incubation at room temperature without change of the incubating medium for 60 min.

The hexazonium pararosanilin seems not significantly to inhibit the acid phosphatase at acid *p*H. However, quantitative data are not available. At neutral or alkaline *p*H the inactivation of acid phosphatase is considerable, indicating a diazonium-type reaction between the hexazonium pararosanilin and the enzyme. When stable diazonium salts are used the inhibition of enzymes is by most authors ascribed to the stabilizer. At acid *p*H the hexazonium salt does not cause appreciable changes in staining for adenosine triphosphatase or 5-nucleotidase, thus permitting combination with these techniques. The excess nitrous acid in the fresh diazonium salt solution seems not to interfere with the staining. Addition of urea to the incubating medium, in order to eliminate the excess of nitrous acid, did not change the histochemical pattern. However, most of the excess nitrous acid can be removed from the hexazonium salt solution by vacuum.

The naphthyl phosphate hexazonium pararosanilin method was employed at *p*H 6·5. This *p*H, chosen empirically, represents a necessary compromise between adequate azo-coupling and optimum enzyme activity. The coupling-rate of hexazonium pararosanilin with α-naphthyl is sluggish between *p*H 4·5 and 5·5. It increases towards neutral *p*H and permits good histochemical localization at *p*H 6·5

or above. Even at *p*H 6·0 or below the localization is better than with other diazonium salts. On the other hand, the acid phosphatase(s) of tissues examined so far are active at these *p*H. In the case of rat liver, acid phosphatase activity at *p*H 6·5 represents about 50 per cent of activity measured at *p*H 5.

The improved localization given by this technique is attributed to the insolubility and substantivity of the azo-dye formed. The dye is resistant to most of the organic solvents and is insoluble in lipids. It is amorphous or microcrystalline. Its colour and form did not change in mounted slides in 10 months. It gave reproducible, constant results in large series of sections of human, rat and mouse tissues. The applicability of this method to nervous tissue, both animal and human (Anderson, P., unpublished observations), deserves emphasis. It should stimulate the re-evaluation of the distribution of acid phosphatase in nervous tissue, where the results with the Gomori lead method are most questionable. It is hoped that the simple modification described will facilitate the histochemical study of the physiological and pathological significance of the somewhat neglected acid phosphatase.

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PATHOLOGY

Vitamin and Coenzyme Content of Hepatomas induced by Butter Yellow

DESPITE the great importance of vitamins and coenzymes to all aspects of metabolism, little attention has been given to the concentration of these compounds in tumours in recent years. In fact, the only systematic study appears to be the work of R. J. Williams and associates[1]. The results of this work demonstrate that the concentration of vitamins in tumours is quite abnormal.

The present investigation was undertaken to study the vitamin and coenzyme contents of one type of tumour in one species. Hepatomas induced by butter yellow (4-dimethylaminoazobenzene) in rats were selected, since they are one of the types of tumour most studied.

Thirty-six male, weanling, albino rats of the Sprague–Dawley strain were fed a 'Purina' diet. After two weeks on this diet, the rats were separately caged and divided into two equal groups. The first group was fed the basal diet as before, while the second was fed the 'Purina' plus 0·06 gm. per cent butter yellow. After 135 days, the animals were killed by decapitation and the livers removed. No tumours were found in the control animals, but of those fed the butter yellow diet 16 of the 18 had large hepatomas. The livers of the control animals, together with the carefully removed hepatomas, were preserved for analysis in the frozen state.

Thiamine assay was conducted with *Saccharomyces cerevisiae*[2], riboflavin assay with *Lactobacillus casei*[3], niacin assay with *Lactobacillus arabinosus*[4], biotin assay with *L. arabinosus*[5], total vitamin B_6 assay with *Saccharomyces carlsbergensis*[6], and pantothenic acid assay with *L. arabinosus*[6] on an enzyme-hydrolysed extract. Vitamin A was detected by the Carr–Price reaction[7], tocopherols by the ferric chloride-α,α-dipyridyl reaction[8] after the removal of interfering substances with concentrated sulphuric acid[9], and ascorbic acid by the 2,4-dinitrophenylhydrazine assay[10].

Diphosphopyridine nucleotide and triphosphopyridine nucleotide were determined by the crystalline alcohol dehydrogenase[11] and *iso*citric dehydrogenase[12] assay methods respectively. The ratio of oxidized to reduced diphosphopyridine nucleotide was determined by the alcohol dehydrogenase method of Holzer *et al.*[13]. Coenzyme *A* was assayed by the arsenolysis method[14].

The results of these determinations are given in Tables 1 and 2.

Table 1. CONCENTRATION OF VITAMINS IN NORMAL LIVERS AND IN HEPATOMAS

Vitamin	Concentration (mean of five determinations, μgm./gm. wet tissue)	
	Normal liver	Hepatoma
Thiamine	2·3	1·1
Riboflavin	26	4
Niacin	160	33
Biotin	0·85	0·17
Total vitamin B_6	9·0	2·4
Pantothenic acid	91	9
Vitamin A	45·1	8·5
Tocopherols	38	5·1
Ascorbic acid	20	25

Table 2. CONCENTRATION OF COENZYMES IN NORMAL LIVERS AND IN HEPATOMAS

Coenzyme	Normal liver	Hepatomas
Total diphosphopyridine nucleotide (μgm./gm. wet tissue)	480	176
Total triphosphopyridine nucleotide (μgm./gm. wet tissue)	230	24
Diphosphopyridine nucleotide/reduced diphosphopyridine nucleotide	2·2	2·9
Coenzyme A (units/gm. wet tissue)	130	12

It is apparent that the concentrations of many vitamins and coenzymes within hepatomas are very abnormal. Indeed, so different are the concentrations from the normal that they offer an explanation of many of the observed metabolic disturbances of tumours. If tumours have a deranged metabolism because of differences in coenzymes and similar factors, it follows that whatever mechanisms are changing the concentrations must be also the primary causes of tumour incidence. As differences in concentration of vitamins within different cells must primarily depend upon cell permeability, it seems a reasonable hypothesis that the change from a normal to a neoplastic cell may be the result of damage to mechanisms responsible for the transfer of vitamins into a cell.

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Effect of *Candida albicans* on the Evolution of Experimental Tuberculosis

In 1954, one of us[1] showed that cultures of *Candida albicans* possess the ability to promote the growth of *M. tuberculosis in vitro*. This finding led to the development of the tracer technique for the detection of tubercle bacilli in pathological material[2]. Recent studies[3] have shown that the polysaccharide fraction of *Candida albicans* is responsible for the *M. tuberculosis* growth-promoting effect of this yeast, and acts, in particular, on tubercle bacilli inhibited in their multiplication by exposure to streptomycin. In the present experiment 60 guinea pigs were given a subcutaneous inoculation in the right groin of 0·05 mgm. (wet weight) of a ten-day culture in 'Tween' albumen medium of *M. tuberculosis* (strain $H_{37}Rv$). Twenty of these were inoculated, at the same time and at the same site, with 1 mgm. (wet weight) of a 5-day Sabouraud culture of *Candida albicans*. Another group of 20 of these guinea pigs was inoculated subcutaneously with 1 ml. of a 5 per cent solution of the growth-promoting polysaccharide fraction of *C. albicans*. Twenty guinea pigs inoculated with tubercle bacilli alone were kept as 'controls'. Another group of 'controls' was formed by 20 guinea pigs which were given a subcutaneous inoculation of 1 mgm. (wet weight) of the 5-day culture of *C. albicans* alone.

All the animals, including those which died and those which were killed in the twelfth week following inoculation, were examined. The lymph nodes near the sites of injection and also those in the left groin, and aliquot parts of liver, spleen and lungs were cultured in an effort to determine whether or not they contained *C. albicans*, *M. tuberculosis*, or both.

Two of the guinea pigs inoculated with a cell suspension of *C. albicans* died, one a month and the other two months after inoculation, from pneumonia due to *D. pneumoniae*. Cultures of the right external iliac lymph nodes showed that they contained *C. albicans*. No evidence of *C. albicans* was found in the left external iliac nodes, the liver, the spleen and the lungs.

Two of the guinea pigs inoculated with a suspension of *M. tuberculosis* (strain $H_{37}Rv$) alone died with an infection due to diplococci less than six weeks after injection. After ten weeks, 8 of the remaining 18 guinea pigs died with tuberculous lesions in the liver, spleen and lungs.

When guinea pigs were inoculated with suspensions of *M. tuberculosis* and *C. albicans* the combined infection resulted in a faster evolution of the tuberculous disease. More than 50 per cent of the animals of this group had died within six weeks of inoculation. Necropsy examination disclosed that all these had lesions in the right external iliac lymph nodes and, in many instances, tubercle bacilli were recovered from the internal iliac lymph nodes, from liver, spleen or lungs. By the end of the twelfth week, cultures of the liver, spleen and lungs of two to three times as many of these animals as of the animals inoculated with tubercle bacilli alone showed evidence of growth of *M. tuberculosis*.

In no instance did these animals show any signs of disease of the liver, spleen or lungs that could be attributed to *C. albicans*. *Candida albicans* was recovered from the regional lymph nodes and, in two instances, from small abscesses that had formed at the site of the inoculation in animals that died within the first six weeks. After this time, *C. albicans* was not recovered again by cultural methods from any tissue.

The addition of the polysaccharide fraction to the bacillary inoculum also increased the death-rate of the guinea pigs from tuberculosis within the first weeks of the experiment. The ratio of tissular infection with *M. tuberculosis* was higher than in animals inoculated with tubercle bacilli alone, but inferior to that of animals inoculated with tubercle bacilli and the living yeast cells.

The death-rate of the animals in this experiment and the number of cultures of *M. tuberculosis* obtained from necropsy material are summarized in Tables 1, 2 and 3.

Table 1. Death-Rate of Guinea Pigs inoculated with Tubercle Bacilli Alone, with Tubercle Bacilli and *C. albicans* Cells, and with Tubercle Bacilli and the Polysaccharides of *C. albicans* in the First Weeks of the Experiment

Interval between infection and death	$H_{37}Rv$	$H_{37}Rv$ and *C. albicans*	$H_{37}Rv$ and polysaccharides of *C. albicans*
2 weeks	—	2	2
3 weeks	—	5	3
4 weeks	1	1	—
5 weeks	—	1	—
6 weeks	1	2	1
Death-rate After 6 weeks	2/20	11/20	6/20

Table 2. Dissemination of Tubercle Bacilli in Animals Dead within Six Weeks of the Experiment

Tubercle bacilli isolated from	Animals inoculated with: $H_{37}Rv$	$H_{37}Rv$ and *C. albicans*	$H_{37}Rv$ and polysaccharide fraction
Right ext. iliac lymph node	2/2	11/11	6/6
Int. iliac lymph node	0/2	4/11	0/6
Left. ext. iliac lymph node	0/2	2/11	3/6
Liver or spleen	0/2	4/11	5/6
Lungs	0/2	4/11	2/6

Table 3. DISSEMINATION OF TUBERCLE BACILLI IN ALL ANIMALS UNDER EXPERIMENT (DEAD OR KILLED AFTER 12 WEEKS)

Tubercle bacilli isolated from	Animals inoculated with: $H_{37}Rv$	$H_{37}Rv$ and *C. albicans*	$H_{37}Rv$ and polysaccharide fraction
Right ext. iliac lymph node	12/20	20/20	20/20
Int. iliac lymph node	11/20	16/20	12/20
Left ext. iliac lymph node	1/20	10/20	7/20
Liver or spleen	6/20	12/20	8/20
Lungs	5/20	13/20	6/20

The results of these experiments show that within the first two months after infection, *C. albicans* increased the invasiveness of the tubercle bacilli. This action can be compared to that of certain extracellular enzymes such as streptokinase or hyaluronidase which are not directly toxic but act as spreading agents for the bacteria which produce them. However, no enzyme that acts on the dissemination of tubercle bacilli *in vivo* has so far been isolated from *C. albicans*. The simultaneous inoculation of 50 mgm. of *C. albicans* polysaccharides reproduced, to a lesser extent, the effect of the living yeast cells by increasing the early death-rate and the dissemination of the tubercle bacilli. The chemical nature of the polysaccharide fraction of *C. albicans* used in this experiment has been studied by Ch. Tanford (personal communication). He pointed out the chemical similarity between this fraction and bacterial 'Dextran U1' described by Greenwood[4,5].

Bacterial dextrans increase the virulence of enterobacteria for rats and mice[6–8]. These dextrans differ in their action from mucin, on one hand, and from the stress-producing substance, adrenocorticotrophic hormone, on the other[9].

The only explanation so far offered for the virulence-enhancing action of dextrans has been proposed by Csalay *et al.*[10], who observed inhibition and destruction of phagocytes in white rats inoculated with dextrans.

The polysaccharide fraction of *C. albicans* represents 10 per cent of the weight of the whole cells[3]. The inoculum of 1 mgm. of yeast cells contained 0·1 mgm. of the polysaccharide fraction. This seems a very small amount of dextrans, unless it is taken into consideration that these cells may have multiplied several times before their ultimate destruction.

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RADIOBIOLOGY

Delayed Recovery of Airborne *Serratia marcescens* after Short-Time Exposure to Ultra-violet Irradiation

THE phenomenon of the re-activation of bacteria after exposure to ultra-violet irradiation is well known[1–4]. The possibility exists that products formed in the medium by the response of some bacteria, either by death or by adaptation, might have influenced the re-activation of neighbouring bacilli.

During a study of freeze-dried *Serratia marcescens* aerosolized from the dried state[5], a question arose concerning the extent of injury incurred by the airborne bacteria as influenced by the quantity of ultra-violet irradiation. This communication describes a re-activation phenomenon associated with such brief exposures.

In our experiments dried organisms were dispersed into cubic-meter chambers[6] with the enclosed air stirred by a fan. Air samples were collected at intervals by means of a Bourdillion-type slit sampler directly on to blood agar base ('BAB', Difco) medium and the plates were incubated immediately. The viable bacterial concentration/litre of aerosol was then plotted on semi-log paper versus time to determine the overall decay in viability. Because physical loss was small compared to the loss of viability, no adjustment for the former was employed. Ultra-violet irradiation was introduced at the top of the chamber by a Westinghouse Sterilamp No. 7824-10, which was turned on for desired time-periods (20–120 sec.) at 90 min. after aerosol dispersal. A sufficient number of samples was taken before exposure to establish the rate of decay in the absence of irradiation. Each aerosol, therefore, served as its own control.

In the absence of irradiation, the numbers of viable airborne bacteria decreased in an exponential manner. It was expected from this finding that exposure to the lethal radiation would cause a sudden decrease in the numbers of viable cells followed by a continuation of the established rate of decay by those bacilli not influenced by the ultra-violet exposure.

As predicted, there was a sudden loss of viable airborne cells on irradiation. The log of the percentage of survivors correlated with duration of ultra-violet exposure. However, subsequent behaviour was unexpected. After completion of the exposure, and for 15–20 min. thereafter, evidence of an increased rate of decay followed by a short period of recovery was noted. In some cases a second increased rate of decay occurred which continued for about 30 min. followed by a second period of recovery, usually 60–75 min. after exposure. The numbers of viable bacilli then remaining airborne were at a level which would have been expected had no ultra-violet exposure been employed. Fig. 1 is a composite illustration of the behaviour of 30 aerosols tested in this manner. Although not all aerosols exhibited two periods of decay and recovery, all but two indicated that the bacteria recovered to the extent shown by the solid line in Fig. 1. In three instances injury was such that no organisms were recovered from the aerosol during a short time-period after irradiation, though viable micro-organisms were present after additional time had passed. This unusual behaviour was associated with the use of sampling medium which had been dried[2,3] for a longer time than was usually employed to clear excess water from the Petri plates.

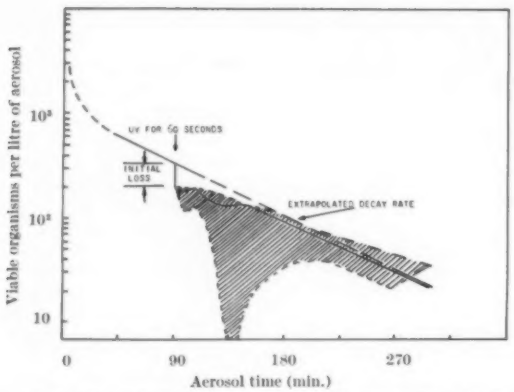

Fig. 1. Composite decay curve of a series of aerosols of powdered *Serratia marcescens* exposed to short periods of ultra-violet radiation. The extent of variation is shown by the shaded area. The most common behaviour is shown by the solid line

The possibility that a Tyndall beam used for measurements of light scatter might have caused photoreactivation[1,4] was tested by turning off the light and holding the sampling plates in the dark until incubation had occurred; the results were the same. Bunting's medium was substituted for the 'BAB' medium, with no change in behaviour. The use of impingers for collection of samples rather than slit samplers in one experiment produced similar results.

It should be noted that all the individuals among the airborne bacilli probably did not encounter an equal exposure to the radiation. But tests have shown that mixing of the aerosolized particles under the conditions employed is complete within 15–20 sec. To have had portions of the aerosol which had contacted maximum radiation pass the sampling port undiluted by other aerosol portions is a very remote possibility. That some bacteria received no radiation does not seem reasonable because of the three instances in which no viable airborne cells were demonstrable for a short time. None the less, the possible existence of conditions of unequal exposure should be kept in mind.

The rate of physical loss of the particulate matter, as calculated by Stokes's law, showed that most of the airborne particles approximated the size of the individual bacterium. Thus, the death or change of one organism in the airborne state could not have influenced by direct physical contact the behaviour of another bacillus. If the recovery phenomenon was associated with the environment of the Petri plates rather than the airborne state, no increased decay rate would have been noted.

Clearly, therefore, the bacteria responded to the initial shock of irradiation such that if required to reproduce immediately they could not do so; but if permitted a period of rest beforehand, they could form colonies. This is possible evidence that significant metabolic activity occurs in airborne cells. The successive periods of increased decay might be caused by absorption and subsequent volatilization of peroxides[7], or could be representative of more than one mechanism of genetic reconstitution. It is further noteworthy that the re-activation phenomenon did not occur when bacteria were aerosolized from liquid suspensions, though this is not conclusive since susceptibility was greatly increased. Thus, the freeze-dry step might have modified or selected bacteria so that they possessed enhanced 'adaptability'. How the single bacillus, enclosed in an adverse micro-environment, can adjust to survive such obvious insult presents an interesting question.

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Relative Availability of Some Strontium-90 Compounds in Soil

Assessment of contamination of man's food chain by strontium-90 through plants is complicated by variables in the plant's source of this isotope. Thus the content of strontium-90 in plants from fall-out may be influenced by foliar absorption[1], stem-base absorption[2], and the vertical distribution of strontium-90 in the soil profile[3]. In cultivated soils, the low mobility of strontium-90 coupled with normal tillage practices eventually will lead to a relatively uniform distribution of strontium-90 within the rhizosphere. Consequently the availability of strontium-90 from soil to plants becomes an important factor in hazard evaluation. We believe information regarding availability, and any change with time thereof, can be obtained by successively cropping soil cultures which have been uniformly contaminated with strontium compounds of varying solubility.

Compounds labelled with strontium-90 were prepared (Table 1) and carefully mixed with small aliquots of dry soil previously passed through a 105-mm. mesh sieve. This mixture was blended with more soil in a V-shell blender to yield 500 gm. dry soil (105° C. basis) with a final activity of 0·1 μc./gm. soil. Each chemical form was prepared in triplicate for each of the three soils (Table 1). Random sampling indicated uniform mixing of strontium-90 throughout the soil mass. Beans (*Phaseolus vulgaris* var. Red Kidney) were grown, two plants per pot, in the greenhouse to blossom stage (32 days). Leaves from each pot were combined, wet ashed, and assayed for strontium-90 by conventional counting procedures. Stem data were also obtained, but are not reported since they substantiated leaf results. Strontium-90 content of tissue was used for evaluating relative availability of strontium compounds, thereby avoiding the uncertainties in chemical extraction procedures discussed by Bowen and Dymond[4]. During intervals between crops, the soil was subjected to wetting and drying but was not cultivated. The first fallow period was 32 days and the second was extended to 141 days.

Uptake from relatively insoluble forms was similar and tenfold less than uptake from insoluble forms in

Table 1

Soil	Harvest No.	μc. of strontium-90/100 gm. dry* bean leaves						
		Form of strontium-90 added to soil						
		$Sr(NO_3)_2$	$SrCl_2$	$SrSO_4$	SrC_2O_4	SrF_2	$SrCO_3$	$SrHPO_4$
Cinebar silt loam (*p*H, 5·4; 1 me Ca‡)	1	150±10†	210±20†	20±1†	19±2†	20±4†	18±2†	19±2†
	2	160±10	260±10	29±7	22±1	20±5	23±7	21±4
	3	110±20	140±16	16±2	13±1	10±1	15±3	14±3
Ephrata sandy loam (*p*H, 8·2; 16 me Ca‡)	1	73±16	79± 4	6·9±0·1	7·7±0·9	4·9±0·9	0·56±0·04	0·46±0·03
	2	72± 3	67±17	5·7±1·1	5·7±0·7	4·2±0·6	0·48±0·03	0·35±0·01
	3	60± 7	61±12	6·7±1·0	6·6±1·1	5·4±1·0	1·0 ±0·1	0·48±0·02
Millville loam (*p*H, 8·0; 30 me Ca‡)	1	60± 2	54± 2	6·2±0·9	5·6±0·9	4·8±0·8	0·69±0·17	0·31±0·02
	2	53± 2	52± 6	4·3±0·2	5·1±0·3	4·9±0·4	0·83±0·04	0·31±0·02
	3	50± 6	45±12	5·2±0·1	4·2±0·8	4·2±0·6	1·6 ±0·3	0·30±0·03

* Leaf tissue dried at 70° C. † Standard deviation. ‡ Ammonium acetate-extractable calcium in me/100 gm. soil.

the acidic Cinebar soil. In calcareous soils, the same relationship between soluble and insoluble forms held with the exception of strontium phosphate and carbonate, which were another order of magnitude less available than the soluble forms. The grouping of the response-levels suggested that moderate differences in solubility were not identifiable when compounds were mixed with soil. The sulphate, suggested by Libby[5] as possibly beneficial in soils contaminated by strontium-90, was no less available than other forms the solubility products of which differ by 1 or 2 orders of magnitude. Soil reactions were clearly important in the relative availability of phosphate and carbonate from basic compared to acidic soils. Apatite formation in alkaline soils containing calcite has been shown to include calcium-like atoms in the apatite lattice, thereby removing strontium from solution[6]. We presume this reaction accounted for the reduction of availability of strontium-90 relative to other forms. Such a direct explanation is not apparent for strontium carbonate.

The low availability of strontium phosphate suggested phosphate fertilization as a means of reducing uptake of strontium-90 from contaminated soils. We were able to demonstrate a 50 per cent reduction in uptake of strontium-90 from basic soils treated with massive doses of phosphate[7]. No reduction was observed on acidic soil.

During three croppings there was no major change in availability of soluble or insoluble forms such that a general trend toward equilibrium was indicated. This suggested a prolonged period of equilibration and substantiated observations previously made on strontium-90 aged several years in the field[8]. In these field-studies strontium-90 aged nearly four years was taken up by plants to the same extent as strontium-85 added at the time of testing. In the present test some changes in availability pertaining to certain compounds in one soil were noted. In acidic soil the availability of all strontium salts decreased in the final harvest. This decrease could not be accounted for by depletion of strontium-90 from the soil. In alkaline soils the rate of change was much slower and in the same direction except for strontium carbonate, which became more available with time.

No significant difference existed between the Ephrata and Millville soils with respect to strontium availability although the uptake from these calcareous soils was 2–3 times less than from the acidic soil. The lower uptake from calcareous soils has been largely attributed to the quantities of available calcium. In partial confirmation of the calcium effect, it has been possible to reduce uptake of strontium-90 as much as 80 per cent by additions of lime or gypsum to Cinebar soil, which is low in calcium[9]. Such amendments are without effect on alkaline calcareous soils[10]. In fact, with the exception of the phosphate treatment mentioned, no treatment procedures have been described which depressed strontium-90 uptake from calcareous soils.

The results obtained to date establish the extent to which uptake of strontium-90 might potentially be reduced through precipitation reactions. Further studies are required to determine whether an appreciable part of this potential can be realized. However, initial experiments with phosphate fertilization[7] do not permit much optimism on this point.

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BIOLOGY

X and *Y* Spermatozoa

A HUMAN spermatozoon contains an *X* or a *Y* chromosome, whereas every human egg contains an *X* chromosome. If, therefore, an *X* spermatozoon fertilizes an egg, the offspring is female; but if a *Y* spermatozoon fertilizes an egg, the offspring is male.

Much effort has, naturally, been expended in trying to separate *X* and *Y* spermatozoa, if only because the separation could be exploited to gratify the wishes of prospective parents. Apart from the

wild idea that an alkaline environment might favour the conception of males or an acid environment that of females, and the less-wild but equally unrewarding idea that there might be immunological differences between *X* and *Y* spermatozoa, three methods have been used to try to identify or separate them. One involves the hypothesis that there is a difference between the size or mass of *X* and *Y* spermatozoa, which would enable them to be separated in a special centrifuge. Experiments to test this possibility have been done on bull spermatozoa by Lindahl[1]; but in spite of the results being hopeful at one time, the conclusion is inescapable that, at present, this hypothetical method of separating *X* and *Y* spermatozoa has not been successful. A serious difficulty encountered in such experiments concerns the variation in the specific gravity of bull spermatozoa according to their degree of ripeness or over-ripeness[2].

A second method of identifying or separating *X* and *Y* spermatozoa depends on the hypothesis that one type has a positive electric charge on its surface and therefore migrates (not swims) to the negative side of an electric field, whereas the other type is negatively charged and migrates to the positive side of the field. Shreder[3], using rabbit spermatozoa, was the first to assert that this happened and the same claim has been made by Gordon[4]. Very recently, Nevo, Michaeli and Schindler[5] have repeated these experiments under well-controlled conditions with bull and rabbit spermatozoa. They found that at normal *p*H's, all bull and rabbit spermatozoa have negative charges on their surfaces and that all of them therefore migrate towards the anode in an electric field.

Electrophoresis experiments of this type are sometimes done on reversibly inactivated spermatozoa. One possible interpretation of positive results on swimming spermatozoa is as follows: the direction in which a swimming spermatozoon travels in an electric field depends on the direction of the resultant of two vectors, one due to the spermatozoon's own forward movement and the other to the force with which it is passively dragged towards one or other side of the electric field. As there is a distribution of velocities in a population of spermatozoa[6], a separation of different 'types' of spermatozoa can obviously be effected in such circumstances, though the separation in no sense implies the existence of oppositely charged sperm surfaces. Nor is there any reason to suppose that *X* spermatozoa swim faster than *Y* spermatozoa, or vice versa.

The third method of identifying *X* and *Y* spermatozoa depends on the hypothesis that there is a difference in the shape or size of the two types. Many measurements of mammalian sperm heads have been made in the hope of finding a bimodal distribution, or a distribution which can be expressed as the sum of two underlying distributions with different means, of some measurable sperm head parameter. No such difference has been found. Shettles, however, in a recent communication[7], reported that human sperm heads fell into two distinct populations without intermediate types. One type of sperm head was small and contained a centrally located round mass, while the other was large and contained a centrally located elongated mass. According to Shettles, these centrally located masses are nuclear material, though nuclear material is generally thought to be uniformly distributed within the mature sperm head, except in the galea capitis, a thin covering over the front end of some mammalian sperm heads. Shettles went on to say that, in one sperm head, three observers independently counted eighteen discrete chromosomes. This is the first time that chromosomes have been 'observed' in a mature sperm head, it having been universally agreed before that discrete chromosomes are not visible in the mature spermatozoon.

Although *X* and *Y* spermatozoa might have been expected to be present in approximately equal numbers, Shettles made no reference to having counted the two types, which is surprising considering the importance of his claim and the ease with which the two types could have been counted.

One photomicrograph, described by Shettles as being of a human sperm head, shows that the head in question is no less than 30μ long, whereas the average human sperm head is 5μ long.

From what has been said, Shettles's claim should clearly not be accepted. The question at issue is: what, in reality, did he observe? Were the round and long black masses distorted vacuoles which occur inside human sperm heads—distorted because of the unusual optical system Shettles used, or because, when dry, human spermatozoa, which are far from being solids of revolution[8], do not always settle on the microscope slide in the same way? Or were the central masses optical artefacts which can easily be demonstrated if crystals in dried human seminal plasma are examined with phase contrast at different focal depths?

To sum up, there is so far no evidence that physical differences have been found between *X* and *Y* spermatozoa.

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The methods of fixation and staining human spermatozoa in the past for bright light and electron microscopy result in alterations and coalescence of the head contents into one mass—a very unnatural state. Consequently, as a result of these changes, the nuclear material of the human spermatozoan head has always appeared very uniform and homogeneous in appearance. It was therefore undesirable to consider the chromatin material in such a state to be normal for the spermatozoan head as it enters the ovum and comes in contact with the egg pronucleus. In his "Developmental Anatomy" (sixth edition, 1954), L. B. Arey states, "The interior of the head contains the tightly packed chromosomes of the sperm cell".

More than a hundred men have now been studied, and the two distinct populations have been repeatedly observed in every semen specimen regarding head and nuclear size and shape, the position, size and shape of the most central chromosomal mass and the pattern of reflected light. The most central mass in each type of head is unequivocally Feulgen-positive, as well

Fig. 1. Living human spermatozoa immobilized in an atmosphere of carbon dioxide. Note most central mass in each type of head. Light adjusted to show third dimension. (Original magnification × 1,000. Print provided [by author] has been reduced to ½)

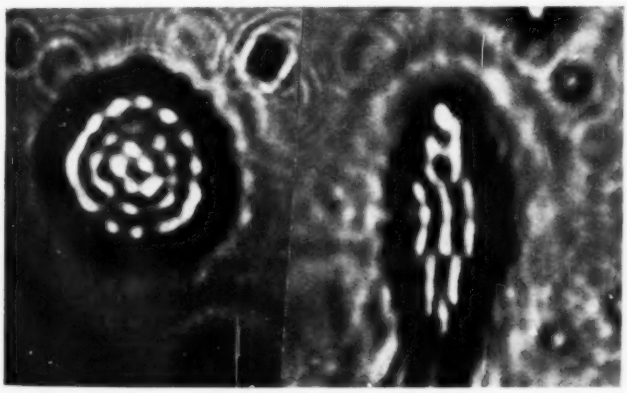

Fig. 2. Dried, unstained human spermatozoon heads showing arrangement of chromosomal material in each type of head. Phase contrast. Heads separated from tails during slight mechanical flattening of heads to facilitate viewing. (Original magnification × 1,000. Print provided [by author] reproduced same size)

as the other compact chromatin masses considered to be the autosomes. Twenty-three chromosomal masses have been counted in some of the rounded type of heads.

The vacuole depicted in the fixed material of the past in bright light and electron microscopic studies can be explained as representing a section taken through the head just beside the most central chromosomal mass (Fig. 1).

Contrary to previous teaching, the ratio of the two types of heads varies from man to man; in most specimens thus far studied, the rounded type predominates. This problem is being studied regarding sex of offspring possibly already produced, frequency of emission and age of individual. Any difference in migratory rates of the two types is also being investigated.

The final enlargement of the illustration referred to by Lord Rothschild and published in my communication of May 21, being enlarged nearly 10,000 times, and its reduction by the printer, do not permit one to figure the original size of the head in microns from the final printing. The length of human spermatozoan heads is often cited to vary from 5 to 8μ; in fact, in some men studied, the larger, normal, elongate types possessed heads 15μ in length.

With a phase-contrast microscope at hand, a semen specimen and glass slides, one can prepare and observe the findings reported in smears directly within just a few minutes. At least 25 different competent observers have been shown preparations; each individual has agreed regarding the two populations.

It has also been found that the two populations can be seen in dried smears viewed in bright light microscopy, with proper adjustment of light intensity. Moreover, the differences in nuclear morphology have been noted in very thin smears of seminal fluid with living spermatozoa immobilized by means of an atmosphere of carbon dioxide (Fig. 1). Furthermore, thin, wet smears observed before, during and after drying under the phase contrast objective of the Zeiss microscope show the two, distinct types of heads. Again, in these the Feulgen test is confirmatory.

There is an exact pattern of arrangement of the Feulgen-positive, concentrically arranged chromosomal material around the most central chromosome in the smaller, rounded type of head, and an ovoid pattern in the more elongate type (Fig. 2). Two, most dependable, cytogeneticists have already repeated and confirmed the findings reported regarding the two, distinct populations.

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READING Dr. Shettles's first communication[1] leaves one with a variety of disturbing thoughts. Should one be able to hurdle the compounded artefacts of air-dried shrinkage and phase-contrast optical aberration, there still remain the matters of interpretation and communication. Agreeing, but only for the moment, with Dr. Shettles that his Fig. 1 shows "no intermediate types", wherein lies his evidence for specifying the "most central chromosome", either in theory or in Fig. 3? Furthermore, in the light of considerable recent disagreement concerning even the extent and outline of the sperm nucleus, based on cytochemical and electron-micrographic preparations, the description of the ultrastructural pattern of nuclear

arrangement seems fragile indeed. Finally, one would hope that some additional technique and confirming evidence might be supplied before assuming too hopefully that "discrete chromosomes" and the "*X* and *Y* chromosomes" can, by this method, be unequivocally recognized. I presume Fig. 3 lost some detail in reproduction.

It is surprising in a study of this potential importance not to find some references to recent work of others in this field, particularly that of C. van Duijn, jun., who has extensively investigated related problems—with conflicting results.

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[1] *Nature*, **186**, 648 (1960).

A North American Xanthoid Crab New to Britain

Investigations of the fauna of artificially warmed docks in Swansea have revealed the presence of xanthoid crabs identified as *Neopanope texana sayi* (Smith). Specimens agree well with descriptions given by Rathbun[1] and Ryan[2], and they have been compared with material in the British Museum (Natural History). The previous known distribution of *N. t. sayi* was along the east coast of North America from Florida northwards to the Gulf of St. Lawrence[1,2] and the present record appears to be the first for the British Isles. There are shipping lines which operate between the east coast of North America and Swansea, and it is no doubt by this means that the crab has been accidentally transported. Wolff[3] has previously suggested that the crabs *Callinectes sapidus* Rathbun and *Rhithropanopeus harrisi* Gould may have reached the coasts of Europe from North America in the ballast tanks of ships, and *Neopanope* has probably been carried to Britain in the same manner. In North America *N. t. sayi* is reported especially from muddy places and on piles among algae[3]. The habitat is similar in Swansea where specimens have been collected regularly among *Ciona intestinalis* (L.) and other fouling organisms[4] on wooden piles, in a region where the floor of the dock is muddy. The occurrence of the crabs on dock piles and timbers would no doubt enable them or their larvæ to find their way into ships' condenser tubes and ballast tanks, in which they could then be transported to a new locality.

In Swansea docks, *Neopanope* occurs together with the shore crab *Carcinus maenas* (L.) and the grapsoid crab *Brachynotus sexdentatus* (Risso). The latter is another immigrant species new to Britain from the Mediterranean[5,6]. Whereas *Brachynotus* is a warm-water species and at Swansea is probably restricted to the warm docks it is possible that *Neopanope* could extend its range to suitable localities outside the docks. To judge from the northward extent of the range of *Neopanope* in North America (as far as the Gulf of St. Lawrence) the species would no doubt be able to tolerate the normal range of temperatures in British waters. In view of the possibility of the further spread of the species in Britain, it seems worthwhile to give brief descriptive notes here.

Carapace (Fig. 1*a*) subhexagonal, markedly convex above, with front advanced and slightly bilobed.

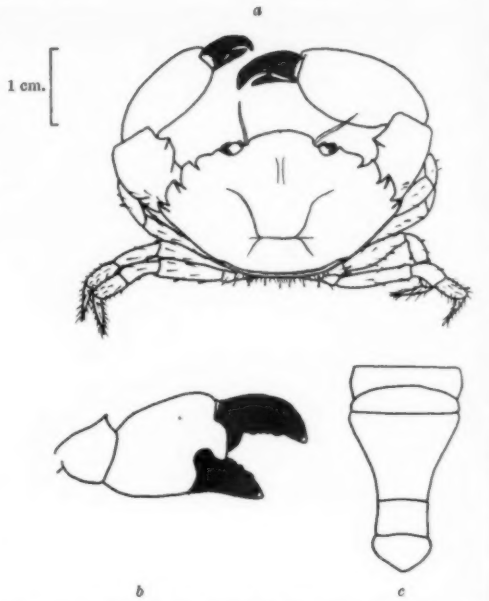

Fig. 1. *Neopanope texana sayi* (Smith) ♂: (*a*) dorsal view of whole animal, (*b*) outer view of right chela (enlarged), (*c*) abdomen from below (enlarged)

Inner orbital angle notched. Antero-lateral borders of carapace with five teeth, including outer orbital angle: second rounded and fused with first; third, fourth and fifth sharp and well defined, third and fourth recurved forwards and fifth pointing laterally. Surface smooth except for fine granulations (not pitted). *Chelæ* (Fig. 1*a* and *b*) slightly unequal in size, inflated and smooth. *Walking legs* (Fig. 1*a*) all subequal in length; distal parts, particularly propus and dactylus, fairly densely fringed with fine setæ. Legs and bases of chelæ scattered with longer, plumose setæ which often appear club-shaped owing to the adherence of detritus. *Abdomen* of male (Fig. 1*c*) with segments 3, 4 and 5 fused; narrowest between fused segments and segment 6; segment 7 triangular. Abdomen of female broadly rounded and very densely fringed with setæ. *Colour* of dorsal surfaces reddish-brown. Ventral surfaces yellow. Fingers of chelæ dark brown. Males with the deeply pigmented area of the fixed finger having its border extended postero-dorsally in a lobe on each side (Fig. 1*b*); pigmented area less extensive in the female and posterior border not lobed. Extreme tips of chelæ lighter in colour. *Size:* the breadth × length measurements (mm.) of the carapace of ten specimens were as follows: males, 30 × 21, 30 × 21, 29 × 21, 29 × 20, 26 × 19, 26 × 18·5, 24 × 17, 23 × 16, 17 × 13; female, 21 × 16.

Neopanope texana sayi differs in several respects from *N. t. texana*, a closely related form, which has, in particular, light-coloured fingers on the chelæ and has sharper and more extensively produced lateral teeth on the carapace[1]. *N. t. texana* is a more subtropical form which is found in the Florida Keys and in the Gulf of Mexico[1]. In Britain the immigrant *Neopanope* shows superficial similarities with native species of *Xantho* but it may be distinguished from the latter genus on several points[7]. In *Neopanope* the carapace is more convex than in *Xantho*, while the surfaces of

the carapace and chelæ are smooth and not pitted. They are pitted in the British forms *Xantho incisus* Leach and *X. pilipes* Milne Edwards. In *Xantho*, moreover, the second lateral tooth on the carapace is relatively more distinct than in *Neopanope* and teeth 3 and 4 are not recurved forwards.

I am grateful to Dr. Isabella Gordon and Mr. R. Ingle for their help at the British Museum (Natural History). Mr. W. A. C. Morris kindly provided information about shipping which operates between North America and Swansea.

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Earthworm Population Studies: a Comparison of Sampling Methods

SVENDSEN[1] showed that the estimate of an earthworm population obtained by hand sorting soil samples was much greater than that by the prevalent method of bringing worms to the soil surface with potassium permanganate solution, and so emphasized that, although laborious, hand sorting was more accurate for population studies. The accuracy of estimates by hand sorting has not been studied but is likely to depend on soil type and conditions, as well as on the time and care taken to examine the sample. One way to estimate accuracy is to see how many worms can be recovered when samples, already hand sorted, are examined again by a different method.

While investigating the role of earthworms when marginal land is reclaimed, their abundance had to be estimated in experimental plots on a hill farm in Lancashire where the soil is relatively shallow, has a poor, unstable structure, and is covered by a surface mat of vegetation. This mat and the underlying soil were usually wet and often waterlogged, and preliminary work showed that the earthworms were confined to the top few inches of the soil profile. Soil samples were taken for hand sorting, and, to estimate the proportion of the population counted in this way, 9 of the sorted samples, 3 from each of 3 experienced workers, were examined again in the following way.

The vegetation was separated from the mineral fraction by gently washing and shaking the sample in a 2-mm. sieve suspended within a 0·5-mm. sieve standing in a bowl of water. Worms were then collected from the vegetation by teasing it in another bowl of water containing a few c.c. of formalin to make the worms wriggle and so be more obvious. After the mineral fraction was washed through the 2-mm. sieve into the 0·5-mm. sieve, so freeing any worms from soil crumbs, this sieve was shaken in the water for a time to allow silt to pass through it. It was then immersed in magnesium sulphate solution, of density 1·2, when the worms floated and were collected.

Table 1 shows that hand sorting recovered 52 per cent of all the worms found in the samples. This corresponded to 84 per cent of the weight, which shows that hand sorting mainly misses the smaller worms. How this selective loss can affect population estimates is well shown by the results for a small species such as *Eiseniella tetraedra*. Hand sorting recovered only 38 per cent of the total number and 57 per cent of the total weight of this species found in the samples and suggested that it comprised 49 per cent of the total number and 18 per cent of the total weight of all species. When the worms recovered by washing are included, *E. tetraedra* comprised 68 per cent of the total number and 26 per cent of the total weight of the population. Clearly hand sorting was unsatisfactory for this habitat, and the washing method, though no more laborious, was preferable.

Table 1. RECOVERY OF EARTHWORMS FROM NINE SOIL SAMPLES BY HAND SORTING AND WASHING

		Worms found by hand sorting	Additional worms found by washing	Total found	Percentage found by hand sorting
All species	Number	256	236	492	52
	Weight (gm.)	13·47	2·55	16·02	84
Eiseniella tetraedra	Number	125	208	333	38
	Weight (gm.)	2·38	1·81	4·19	57

In similar tests with soil samples from grassland with no surface mat on a light, well-drained soil at Wisbech, and from a heavier, well-drained soil at Rothamsted, 89 per cent of the total number and 95 per cent of the total weight found was recovered by hand sorting, which was also much quicker than washing. In contrast, hand sorting samples from an old arable field with heavy soil and poor structure recovered only 59 per cent of the total number and 90 per cent of the total weight found and was no quicker than washing.

The washing method not only provides a check on the efficiency of hand sorting, but, for some habitats, also provides a much more accurate estimate of the earthworm population. The washing method has the further advantage that it can be adapted to extract earthworm egg capsules and so estimate all stages of the population.

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Modification of the Neurocranium in *Zygaena malleus* and the Nature of the Optic Stalk in Selachii

GENERALLY in Selachii, between the nasal and auditory capsules, on each side, are the orbits in which the eyes are lodged. The orbit is overhung by the supraorbital cartilage which extends anteriorly and posteriorly to the orbit as the pre- and post-orbital processes respectively. The optic capsule, which is represented by the sclerotic cartilage, does not fuse with the brain-case, as the nasal and auditory capsules do; but it is held away from the orbital wall by the cartilaginous optic stalk, which is proximally fused with the orbital wall.

In *Zygaena malleus* only the most anterior and most posterior parts of the supraorbital cartilage are represented, forming the pre- and post-orbital processes. The orbit (Fig. 1, *Or.*) has retained a secondary

position owing to the abnormal development and extension of these processes. The preorbital process (*Pr.Or.Prs.*) is a stout cartilage arising far away from the brain-case and extends laterally to form a bifurcated plate, the anterior lobe of which is extended anteriorly and arching postero-ventrally, and the posterior lobe extends laterally. The postorbital process (*Pt.Or.Prs.*) is somewhat flattened, doubly twisted, and abnormally extended laterally from the anterior border of the auditory capsule to become distally fused with the posterior lobe of the preorbital process. The eye is located in the space lying between the anterior lobe of the preorbital process and its posterior lobe, which is fused with the distal end of the postorbital process. Thus the original orbit, generally found in selachian neurocrania adhering to the orbital wall, is shifted laterally according to the abnormal, lateral extension of both the pre- and post-orbital processes. Such position of the orbit is considered to be secondary and due to the modification to which the neurocranium is subjected.

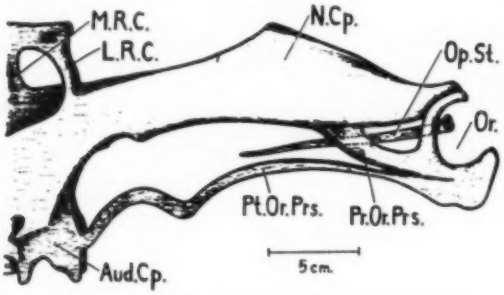

Fig. 1. *Zygaena malleus*. Dorsal view of the neurocranium. *Aud.Cp.*, auditory capsule; *L.R.C.*, lateral rostral cartilage; *M.R.C.*, median rostral cartilage; *N.Cp.*, nasal capsule; *Op.St.*, optic stalk; *Or.*, orbit; *Pr.Or.Prs.*, preorbital process; *Pt.Or.Prs.*, postorbital process

The optic stalk (*Op.St.*) is a long, tapering, cartilaginous rod extending inwards from the orbit, until nearly half-way from it to the orbital wall. It is made of softer cartilage than the neurocranium, and provided with a well-developed terminal expansion against which abuts the eyeball. On reviewing the literature concerning the nature of the optic stalk in Selachii, two different views were found; the first considers the optic stalk as a lateral extension from the lateral surface of the orbital wall[1], and the second believes that the optic stalk appears independently and then becomes secondarily fused with the orbital wall[2,3]. In *Zygaena malleus* it is seen that the optic stalk appears independently and extends inwards from the eye in the direction of the orbital wall. This case shows that the selachian optic stalk, in general, appears independently and extends from the eye towards the orbital wall with which it is secondarily fused. Such fusion easily occurs as the orbit lies close to the orbital wall, and it seems to be a means of support. In *Zygaena malleus*, where the orbit is lying far away from the orbital wall, the optic stalk fails to fuse with it. Gegenbaur[4] states that the base of the optic stalk in Selachii is always composed of somewhat firmer tissue than the rest of the stalk, and is considered by him to belong to the neurocranium rather than to the optic stalk. Hamdy[3] and El-Toubi and Hamdy[5] observed that the selachian optic stalk is always composed of homogeneous tissue. It seems that what was observed by Gegenbaur in this respect is nothing but the place of the secondary fusion of the base of the optic stalk with the orbital wall.

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Plant Hormone Activity: Stilbœstrol applied to the Wheat Seedling

The presence in plants of substances having œstrogenic activity has been known for some time, œstrone, œstriol and œstrogenic *iso*-flavones having been isolated from a number of plants[1]. Many plant hormones are also known to exhibit hypo-glycæmic activity in animals. On the other hand, this may be the result of inhibition of insulinase and not a hormonal effect, although the auxin and insulinase-inhibiting activities of a number of indole-acids, chloro-phenoxyacetic and chloro-benzoic acids run parallel[2]. There is also evidence to show that the sex of flowers of the normally dicœcious *Melandrium dioicum* can be partially influenced by mammalian œstrogenic and androgenic hormones[3].

This communication reports, as a further example of the complementary reaction of plants to substances with hormonal activity in animals, the 'hormonal' activity of synthetic œstrogens on the roots of the wheat seedling.

Fig. 1 shows the tropic response of the roots of wheat grains germinated on the surface of an agar water gel containing 50 p.p.m. of stilbœstrol. This response followed when the roots approached the surface at an angle; those which touched it in a near vertical position grew into the gel, though at a rate only about a twentieth that of roots growing into pure agar gel. A vigorous and certain response was also only obtained when the gel was freshly prepared, probably because this concentration of stilbœstrol is about three times its true solubility at room temperature and its strength gradually falls as crystallization takes place.

An alternative method of demonstrating the effect was to germinate the grain in water until the roots

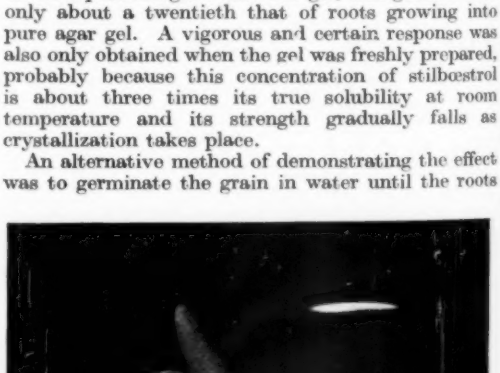

Fig. 1. Curvature of roots of germinating wheat induced by stilbœstrol

were a few millimetres long, when it was transferred to a block of pure agar gel placed in a Petri dish. By placing the grain so that 1–2 mm. only of the root tip overhung the edge of the agar and keeping the dish covered, the roots were kept sufficiently moist to maintain growth. Stilbœstrol was applied as a minute crystal to one side of the tip. Curvature of the root was first noticeable after approximately 2 hr., the curvature indicating increased growth on the side to which stilbœstrol had been applied. Curvature also occurred in other tests, following the application of stilbœstrol, when the root was in a vertical position. When stilbœstrol was applied mixed with lanolin or 'Vaseline', in the manner used successfully in the testing of auxin activity, no response was obtained. The appearance suggested that the greasy base failed to adhere to the moist root surface.

Using this method of direct application to the root, an attempt was made to distinguish the sensitive region. Curvature occurred in the region of extension growth a little way behind the tip, but application of stilbœstrol at this point was not effective. The sensitive region was found to be approximately the root-cap, and application outside this area had no effect.

The coleoptile appeared to be insensitive to stilbœstrol when this was applied in agar as in Went's coleoptile test[4], or as a minute crystal applied to one side of its surface, either unbroken or abraded or at the surface of a cut made completely through the tissue. The application was made at various regions near the tip and at different stages in the growth of the coleoptile. Tests were made on grains held in the dark and in the light, but no curvature was obtained in any of these experiments.

Activity of Allied Substances. E. C. Dodds and his co-workers found œstrogenic activity in other compounds possessing the basic di-phenyl structure of stilbœstrol[5]. Five of these compounds and three natural steroids have been tested.

Diphenylethane and stilbene had no activity. 4·4 Dihydroxydiphenyl induced a slight curvature, but 2·2 dihydroxydiphenyl was inactive. No activity was shown by œstrone, œstradiol, œstradiol benzoate and testosterone.

Phenol in agar in a range of concentration from 0·1 to 400 p.p.m. produced no curvature, but at 400 p.p.m. it inhibited growth. When applied direct to the root, the two dihydroxydiphenyls damaged the tissues at the point of application and the meristem afterwards died. Dilution by thorough mixing with five to ten parts of an inert substance was necessary to prevent harmful effects. In these experiments wheaten flour was used as the diluent.

When hexœstrol was applied direct to the root, curvature followed as with stilbœstrol. Less-certain and sometimes feeble results were obtained, however, from a solution in agar. This was probably the result of its lower solubility in water as compared with stilbœstrol. Approximate figures for the solubilities were measured, using a *p*-nitroaniline reagent[6] and comparing the colour developed with a standard curve prepared with warm solution. They were 7 and 15 p.p.m. respectively.

Interpretation of the results is complicated by the different solubilities in water of the materials tested. In general, it is probable that the natural steroids, which were ineffective, are less soluble than the synthetic œstrogens, and this will affect their rate of movement into and within the root. The same consideration applies to diphenylethane and stilbene, both of which were found by Dodds to possess activity. They had no activity when applied to the root, but the more soluble 4·4 dihydroxydiphenyl, which also possesses œstrogenic activity, produced slight curvature. By evaporating solutions saturated at room temperature and weighing the residue, the solubilities of stilbene and 4·4 dihydroxydiphenyl were found to be of the order of 10 and 70 p.p.m. respectively. The damage to the root tissue following the direct application of the dihydroxydiphenyls, which was not observed with any of the other substances, may also be due in part to their greater solubility.

Stilbœstrol was completely ineffective in producing curvature in the coleoptile under the conditions tested, which include those usually employed to demonstrate and measure the auxin stimulus on cell extension. This leaves its mode of action unexplained. A stimulating effect of stilbœstrol, œstrone and œstradiol on cell division in mouse ear epidermis held in tissue culture has been reported[7]. Such an effect, if it can be demonstrated in roots, would provide an explanation of our observations, but it is apparently contradicted by the considerable check in growth of those roots which actually grew into the gel containing stilbœstrol.

Our thanks are due to Sir Charles Dodds and Prof. L. J. Audus for their advice in the preparation of this communication.

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Relative Lengths of Leaf Sheath and Blade with Reference to the Developmental Stages of the Rice Plant

Different vegetative characters are taken into consideration for describing the individual groups and varieties of rice (*Oryza sativa* L.), but little importance has so far been attached to the behaviour of the plants with regard to the ratio of the length of leaf sheath to that of leaf blade. With the view of studying the sequences of the ratios in all the successive mature leaves and their relationship with certain important developmental stages, the present investigation was undertaken with three rice varieties, namely, *F.R.*13*A* (aman), *Satika* (aus) and *C.B.*1 (boro).

Seeds of the three varieties were directly sown in pots on June 10, 1959. The lengths of leaf sheath and blade were measured periodically, and this recording was continued up to the harvesting time. The individual length of the leaf sheaths and leaf blades as indicated in the graphs (Figs. 1 and 2) represented an average of about 21 measurements.

The number of leaves on the main culm was recorded to be 18, 11 and 14 in *F.R.*13*A*, *Satika* and *C.B.*1 respectively; their hard culm bases were

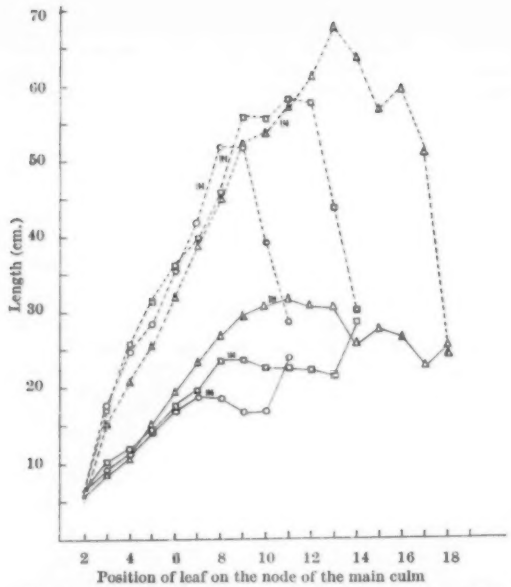

Fig. 1. Relation of mean length of the successive mature leaf sheath (——) and leaf blade (----) in cm. of the second to ear leaves of *F.R.*13*A* (△), *Satika* (○) and *C.B.*1 (□)

found to consist mostly of 10, 7 and 8 crowded nodes. Extension of internodes started later after the respective last nodes of the culm base. Ramiah and Rao[1] mention that during the tillering phase and until the formation of primordium ear, a rice plant does not show any elongated internodes, excepting the deep-water rices; vigorous shoot growth starts only with the commencement of ear formation. But in the present study the initiation of ear primordium occurs at a stage when 5, 1 and 3 long internodes have already been formed in respectively *F.R.*13*A*, *Satika* and *C.B.*1.

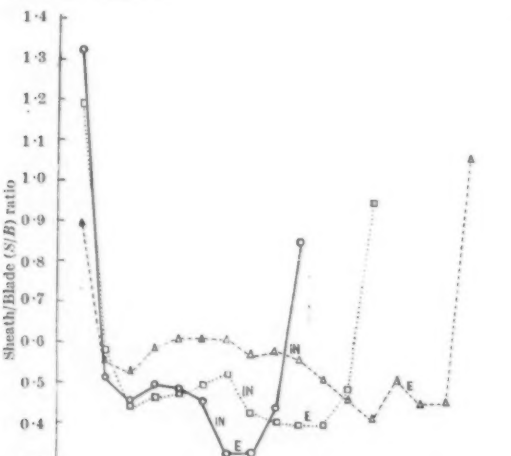

Fig. 2. Sequences of the sheath/blade ratios in the successive mature leaves of *F.R.*13*A* (△), *Satika* (○) and *C.B.*1 (□). *E* and *IN* indicate respectively stage of ear initiation and that of internode elongation

The sheaths in almost all the three varieties continued to increase in length until the beginning of internode elongation. The length of leaf blades, however, showed a gradual rise from the second to the eighth in *Satika* and to the eleventh in *C.B.*1. In both of them with the formation of long internodes the length of the leaf blade recorded an abrupt jump and continued to rise until a fall was noted in the last three leaves (Fig. 1).

The sheath/blade ratio of the second leaf was usually more than unity in *Satika* and *C.B.*1 and slightly less in *F.R.*13*A*. In most of the later-formed leaves, the ratios were, however, far less than unity. In *Satika* and *C.B.*1 the sheath/blade ratios increased distinctly from the fourth leaf onwards up to the leaf developing before the formation of long internodes, but with the initiation of internode elongation they showed a definite and gradual fall up to the eighth and eleventh leaf respectively, that is, the fourth leaf from the terminal ear leaf (Fig. 2).

The ratios in the tenth leaf of *Satika* and thirteenth leaf of *C.B.*1 (that is, the second from the terminal one) showed a sharp rise from those of the leaves developing in the culm elongation phase, when the ear primordium was noted to have already developed fairly distinctly. In the ear leaf of *Satika* and *C.B.*1, the ratio was slightly less than unity, which was more in *F.R.*13*A*. The variation in leaf size developing during the ear formation may result from the great consumption of energy and a drop in carbon/nitrogen ratio as indicated by Nagai[2]. Although ear formation becomes apparent from the ear leaf having a blade relatively shorter and broader, this indication could also be noted even much earlier from the size variation of the leaf developing just before the ear leaf.

The culm elongation phase has been noted to be accompanied by a definite fall in sheath/blade ratios, when the main culm forms more than half the total number of leaves in *F.R.*13*A*, *Satika* and *C.B.*1. Ear formation is evident much earlier from the higher sheath/blade ratio of the leaf, second from the terminal leaf.

I am grateful to Dr. B. C. Kundu, director of this Institute, for the facilities to carry out the work and also to the National Institute of Sciences of India for the award of a Senior Research Fellowship.

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SOIL SCIENCE

Ammonia released on Treating Soils with *N* Sodium Hydroxide as a Possible Means of predicting the Nitrogen-supplying Power of Soils

The only reliable method at present available for estimating the potential nitrogen-supplying power to crops of the organic nitrogenous fraction of soils is the incubation procedure. In this, soils are incubated under optimum conditions of moisture and temperature for periods of two weeks or longer and the quantity of nitrogen mineralized taken as a measure of their nitrogen-supplying power. Many workers

have shown good correlations between the amount of nitrogen mineralized during incubation and crop production. These results have been well summarized by Harmsen and van Schreven[1]. The main drawbacks of the incubation method are the length of time required and the relative tediousness involved in extracting and determining mineralized nitrogen. A quicker method which also requires less manipulation is obviously desirable, particularly where large numbers of samples are being tested, such as in advisory work.

In some studies being carried out with the view of determining whether any single fraction of the soil organic nitrogen contributed to the nitrogen mineralized during incubation, it was noted for a number of soils that the amount of ammonia released on treating them with *N* sodium hydroxide was positively correlated with the amount of nitrogen mineralized during incubation of the soils. In order to see if this relationship held for a large variety of cultivated soils the two methods were tested on 48 garden and allotment soils ranging in texture from sands to clays, with total nitrogen of 0·01–0·35 per cent, and *p*H of 4·7–8·2, and including 13 soils containing free chalk. The soils were sampled during November and December after digging and subjected to the two procedures within two weeks of being air-dried. After rubbing the soils through a 2-mm. sieve, the incubation test was carried out as previously described[2] (3 weeks incubation at 28° C. with moisture content adjusted to 33 per cent of the maximum water-holding capacity of the soils) and mineral nitrogen was extracted with *N* sodium chloride and determined by the Bremner–Shaw modification[3] of the Conway microdiffusion method. The air-dried soils were also analysed for extractable mineral nitrogen in the same way, the differences between the two results giving the amounts of nitrogen mineralized during incubation. The 'Perspex' cells used in the Bremner–Shaw method were also found to be very satisfactory for determining the release of ammonia on treating the soils with alkali. After preliminary studies on the effect of varying the soil : alkali ratio, degree of agitation and time, the following procedure was adopted : 2 gm. air-dried 2-mm.-sieved soils and 5 ml. *N* sodium hydroxide were placed in the outer ring of the cell without mixing, and 2 ml. 2 per cent boric acid was placed in the central chamber. After sealing the lid with the gum acacia fixative the cell was rotated gently for about 30 sec. to mix the contents of the outer ring, allowed to stand for about 1 hr., agitated again for about 30 sec. and then placed in an incubator at 28° for 40–42 hr. The ammonia absorbed by the boric acid was determined by titration with standard acid using a methyl-red–methylene blue indicator[4].

Fig. 1 shows the relationship between results obtained by the two methods. In the diagram the soils are indicated in three groups, namely, calcareous soils, those with $pH > 6$ and those with $pH < 6$. The linear correlation coefficient is 0·845 and is very highly significant. The pattern of the relationship appears to be independent of soil *p*H and the presence of free chalk. Most of the acid soils give relatively low values, while most of the chalky soils give high values, for both determinations. The amount of ammonia released on treating the soils with *N* sodium hydroxide averaged four times that mineralized during incubation, and accounted for an average of 8 per cent of the total nitrogen present in the soils. The action of the alkali presumably results in the hydrolysis of a certain amount of the organic nitrogenous materials present, resulting in the release of ammonia from the amide linkages of proteins and possibly also from other sources[5].

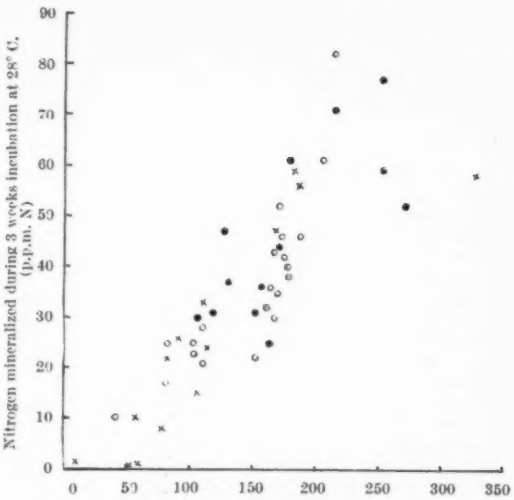

Fig. 1. Relationship between nitrogen mineralized in soils during 3 weeks incubation and ammonia released on treating soils with *N* sodium hydroxide. Linear correlation coefficient = 0·845. ●, Calcareous soils; ○, soils with $pH > 6$; ×, soils with $pH < 6$

In spite of the high correlation between the results obtained by the two methods, individual variations are fairly high. Hence only an approximate prediction of nitrogen mineralized during incubation can be obtained from a knowledge of the amount of ammonia released on treating the soil with *N* sodium hydroxide. However, the method may be useful for advisory purposes and also for screening soils before applying the more tedious incubation procedure.

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Aluminium Interlayers in Clay Minerals, Montmorillonite and Vermiculite : Laboratory Synthesis

Aluminium interlayers in pure montmorillonite and vermiculite have been produced experimentally as proposed in an earlier communication[1]. These aluminium interlayers resulted in a stable 14-Å. spacing and a reduced cation exchange capacity analogous to the stable spacing[2–4] and reduced exchange capacity[4] encountered in 'chloritized'[1] soil clays.

The interlayers were experimentally introduced under conditions resembling those where interlayers are naturally found : abundant aluminium ions and

a *p*H at about 5. Aluminium chloride (0·1 *N*) solution was brought to *p*H 5 by a slow dropwise addition of 1·0 *N* sodium hydroxide. The solution was stirred continuously and vigorously. The montmorillonite and vermiculite samples were washed by five centrifugations and suspensions in the aluminium solution, and the samples were then suspended in the solution and set aside for fifteen days, being occasionally shaken.

The treated samples were saturated with potassium and afterwards heated at 100° C. for 2 hr. and then at 300° C. for 2 hr. The smoothed tracings of X-ray diffraction patterns of the oriented specimens of treated montmorillonite and vermiculite with aluminium interlayers are given in Fig. 1. The 14-Å. spacing of the treated minerals did not close to 10 Å. even when heating followed potassium saturation. In contrast to this stability, the original montmorillonite and vermiculite closed to 10 Å. on saturation with potassium alone. Thus the laboratory introduction of aluminium interlayers into montmorillonite and vermiculite produced clays that resembled the chloritized soil clays in their 14-Å. spacing and the stability of this spacing.

Aluminium interlayers were also produced by repeatedly washing pure clays with 1·0 *N* aluminium chloride solution, and then raising the *p*H of the suspension to 5 and setting the suspension aside for fifteen days.

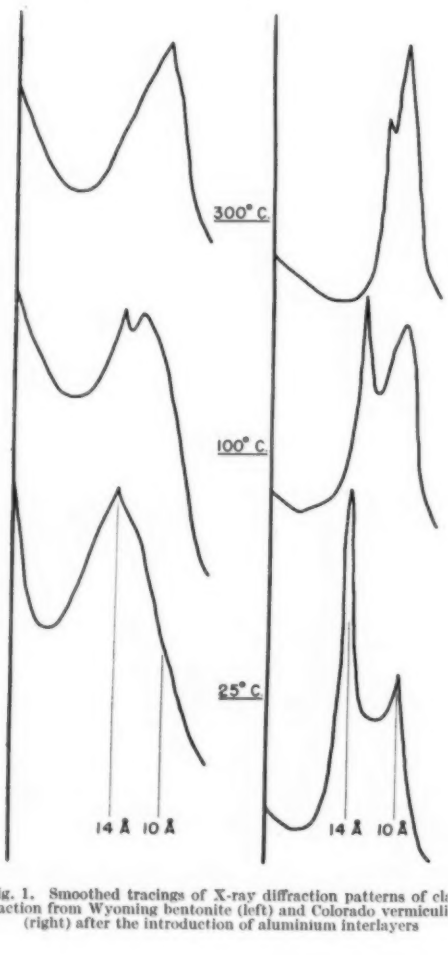

Fig. 1. Smoothed tracings of X-ray diffraction patterns of clay fraction from Wyoming bentonite (left) and Colorado vermiculite (right) after the introduction of aluminium interlayers

Table 1. Cation Exchange Capacities of Montmorillonites and Vermiculites, Before and After Introduction of Aluminium Interlayers

Sample	Fraction size	Cation exchange capacity milliequiv. per 100 gm. Before	After
Montana vermiculite	$<2\mu$	107·7	59·7
Colorado vermiculite	$<2\mu$	132·9	62·1
Putnam clay	$<0{\cdot}2\mu$	76·8	59·8
Wyoming bentonite	$<2\mu$	91·7	63·9

The introduction of aluminium interlayers in both montmorillonite and vermiculite caused a striking decrease in the cation exchange capacity of these minerals as determined by the method of Sawhney *et al.*[5]. Introduction of the interlayers decreased the exchange capacity 45 and 53 per cent in the vermiculite and 23 and 30 per cent in the montmorillonite (Table 1). The laboratory introduction of aluminium interlayers into montmorillonite and vermiculite thus produced clays that resembled the chloritized soil clays[4] in their reduced exchange capacity.

When chloritized soil clays were extracted with citrate[3] for the removal of aluminium interlayers, their exchange capacity increased and their 14-Å. spacing collapsed to 10 Å. on saturation with potassium[4]. Also, when the samples with aluminium interlayer produced in the laboratory were extracted with citrate, the 14-Å. spacing collapsed to 10 Å. on potassion saturation, and the exchange capacity increased to that of the original minerals.

The laboratory formation of aluminium interlayers in expanding layer silicates, and the similar behaviour of the laboratory products and the natural soil clays lend further support to the hypothesis that 'chloritization' of soil montmorillonite and vermiculite gives rise to the stable 14-Å. spacing, which has characteristics tending towards those of chlorite. The different degrees of chloritization in soil clays is shown by the varying stability of the 14-Å. spacing, and also by the varying increase in exchange capacity elicited by the removal of aluminium interlayers[4]. The aluminium interlayers are probably comprised of the polymers[6] of $Al(OH)_2^+$ ions, which are most abundant at *p*H 5.

Aluminium interlayer formation or 'chloritization' in expanding layer silicates in soils is analogous to diagenesis of chlorite in sediments[7]. The cationic environment of sediments produces brucitic interlayers as contrasted to the gibbsitic interlayers observed in soil clays. The chloritization process in both sediments and soils produces a 14-Å. spacing, more stable than that of vermiculite but less stable than that of hydrothermal chlorite.

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FORTHCOMING EVENTS

Monday, July 18—Friday, July 22

THE NATIONAL FOUNDATION (U.S.A.) (at Church House, Westminster, London, S.W.1), at 9.30 a.m. daily—First International Conference on "Congenital Malformations".

Tuesday, July 19

PLASTICS INSTITUTE (at the British Plastics Federation, 47/48 Piccadilly, London, W.1), at 2.15 p.m.—Annual General Meeting.

Wednesday, July 20

ROYAL SOCIETY (at the Royal Institution, 21 Albemarle Street, London, W.1), at 10.15 a.m.—Prof. C. D. Darlington, F.R.S.: "The Chromosomes and the Theory of Heredity". 2.30 p.m.—Sir Alexander Todd, F.R.S.: "New Horizons in Organic Chemistry" (Tercentenary Lectures).

ROYAL SOCIETY (at the Beveridge Hall, University of London, London, W.C.1), at 10.15 a.m.—Sir Christopher Hinton, K.B.E., F.R.S.: "The Evolution of Nuclear Power Plant Design". 2.30 p.m.—Prof. C. F. Powell, F.R.S.: "The Study of Nuclear Disintegrations produced by Particles of Energy" (Tercentenary Lectures).

ROYAL SOCIETY (at The Royal College of Surgeons, Lincoln's Inn Fields, London, W.C.2), at 10.15 a.m.—Prof. P. B. Medawar, C.B.E., F.R.S.: "The Problems of Transplantation". 2.30 p.m.—Prof. A. L. Hodgkin, F.R.S.: "The Physics and Chemistry of Nervous Conduction" (Tercentenary Lectures).

Thursday, July 21—Wednesday, July 27

INSTITUTION OF ELECTRICAL ENGINEERS, ELECTRONICS AND COMMUNICATIONS SECTION (in association with the INTERNATIONAL FEDERATION FOR MEDICAL ELECTRONICS, at Olympia, London, W.14)—Third International Conference on "Medical Electronics".

Saturday, July 23

ROYAL SOCIETY (at the Beveridge Hall, University of London, London, W.C.1), at 10.15 a.m.—Dr. Dorothy Hodgkin, F.R.S.: "Molecules in Crystals" (Tercentenary Lecture).

ROYAL SOCIETY (at the Royal Institution, 21 Albemarle Street, London, W.1), at 10.15 a.m.—Prof. A. C. B. Lovell, O.B.E., F.R.S.: "The Investigation of the Universe by Radio Astronomy" (Tercentenary Lecture).

ROYAL SOCIETY (at the Royal College of Surgeons, Lincoln's Inn Fields, London, W.C.2), at 10.15 a.m.—Prof. V. B. Wigglesworth, C.B.E., F.R.S.: "The Metamorphosis of Insects" (Tercentenary Lecture).

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURER (man or woman) IN CHEMISTRY—The Principal, Royal Holloway College (University of London), Englefield Green, Surrey (July 20).

LABORATORY HISTOLOGICAL TECHNICIAN, to train and work in electron microscopy—The Secretary, Institute of Neurology, National Hospital, Queen Square, London, W.C.1 (July 20).

SENIOR LECTURER IN PHYSICAL CHEMISTRY; and a LECTURER IN ELECTRICAL ENGINEERING (ELECTRONICS)—The Registrar, Lanchester College of Technology, Priory Street, Coventry (July 20).

FEMALE RESEARCH ASSISTANT (preferably with experience of survey work, interviewing and typing), for social work in a programme of human genetical research—The Secretary, Department of Biology as Applied to Medicine, Middlesex Hospital Medical School, London, W.1 (July 22).

LECTURER IN ORGANIC CHEMISTRY at the University of New England, Armidale, N.S.W., Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, July 22).

LECTURER IN PHYSICS—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (July 22).

GRADUATE IN BIOLOGY (male or female, with experience of routine laboratory techniques, in particular biological assay), to work in Central London on testing spermicidal products and to undertake research into methods of fertility control—Mrs. R. Peers, International Planned Parenthood Federation Medical Committee, 19 Clarendon Road, London, W.11 (July 23).

LECTURER IN PHYSICS, and a LECTURER (graduate in pharmacy or physiology, with experience or specialization in pharmacology) IN PHARMACOLOGY—The Bursar, College of Advanced Technology, Gosta Green, Birmingham 4, quoting "D" (July 23).

RESEARCH STUDENTS (2) (graduates in chemistry, biochemistry or physiology) IN THE CANCER RESEARCH DEPARTMENT, for work on the biochemical and immunological aspects of carcinogenesis—The Registrar, The University, Nottingham (July 23).

ASSISTANT LECTURER IN PSYCHOLOGY—The Registrar, The University, Hull (July 25).

RESEARCH ASSISTANT (with a physics degree and a good knowledge of electronics) IN THE GEOPHYSICS SECTION OF THE GEOLOGY DEPARTMENT—The Professor of Geophysics, Imperial College of Science and Technology, London, S.W.7 (July 25).

SENIOR LECTURER or LECTURER (male, British, with a first- or second-class honours degree in physical metallurgy or equivalent, and preferably some teaching experience) IN THE CHEMISTRY AND METALLURGY DEPARTMENT, R.N. College, Greenwich, London, S.E.10—The Director (P/3), Naval Education Service, Admiralty, London, S.W.1 (July 25).

TEMPORARY ASSISTANT LECTURER IN PHILOSOPHY or an ASSISTANT LECTURER IN PHILOSOPHY—The Registrar, University College of North Staffordshire, Keele, Staffs (July 29).

ASSISTANT LECTURER IN THE DEPARTMENT OF METALLURGY—The Registrar, The University, Manchester 13 (July 30).

JUNIOR LECTURER IN BIOCHEMISTRY—The Secretary, Medical College of St. Bartholomew's Hospital, West Smithfield, London, E.C.1 (July 30).

LECTURER (medical or dental graduate) IN DENTAL BACTERIOLOGY—The Secretary, The University, Edinburgh (July 30).

LECTURER or ASSISTANT LECTURER IN MATHEMATICS—The Secretary, Royal College of Science and Technology, Glasgow (July 30).

LECTURER (preferably with experience in teaching biochemistry to medical and science students) IN BIOCHEMISTRY—The Secretary, Medical College of St. Bartholomew's Hospital, West Smithfield, London, E.C.1 (July 30).

LECTURER IN BACTERIOLOGY at the Western Infirmary—The Secretary of University Court, The University, Glasgow (August 1).

PEDOLOGIST AND SOIL SURVEYOR (honours graduate in science or agricultural science with some years research experience, preferably in soils investigations) at the Regional Centre, Commonwealth Scientific and Industrial Research Organization, Brisbane, Queensland, to carry out soil surveys and pedological investigations in a variety of regions to assist in the numerous aspects of land development and irrigation, to facilitate soil fertility studies and to establish fundamental pedological principles of use in the development and application of soil sciences—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 270/207 (August 6).

SENIOR BACTERIOLOGIST, SENIOR CONSULTANT (with a degree in human or veterinary medicine or microbiology with Ph.D. or equivalent) IN THE NATIONAL BIOLOGICAL STANDARDS LABORATORIES, Canberra, for the supervision and recruitment of staff to assay the potency, purity and safety of human and veterinary bacterial and therapeutic agents—The Director-General of Health, Department of Health, Canberra, Australia (August 6).

ANALYST (with a degree in chemistry or biochemistry, or considerable experience in analytical chemistry) IN THE DEPARTMENT OF CHEMICAL PATHOLOGY—The Registrar, The University, Leeds 2 (August 8).

LECTURER IN PSYCHOLOGICAL MEDICINE—The Secretary of University Court, The University, Glasgow (August 13).

ASSISTANT LECTURER (with a veterinary or medical qualification or a degree in zoology) IN HISTOLOGY AND EMBRYOLOGY—The Secretary, Royal Veterinary College (University of London), Royal College Street, London, N.W.1 (August 15).

LECTURER IN GEOGRAPHY at Rhodes University, Port Elizabeth, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa and London, August 15).

LECTURER (with a good honours degree in physics or equivalent and preferably teaching experience) IN THEORETICAL PHYSICS at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, August 15).

LECTURERS IN PHYSICAL AND IN ORGANIC CHEMISTRY at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, August 15).

ANALYST, Assistant Experiment Officer grade, for experiments on sugar beet, at first near Lincoln and later near Bury St. Edmunds—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (August 20).

ASSISTANT EXPERIMENTAL OFFICER or EXPERIMENTAL OFFICER (graduate in a biological science or agriculture), for experiments on sugar beet, first at Dunholme Field Station, near Lincoln, and later near Bury St. Edmunds—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (August 20).

CHAIR OF THEORETICAL PHYSICS in the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, August 31).

LECTURER IN ARCHÆOLOGY—The Secretary of University Court, The University, Glasgow (August 31).

PRINCIPAL (with high academic qualifications and appropriate educational and administrative experience) OF THE NORTHERN POLYTECHNIC—R. H. Currell, F.C.A., Clerk, Northern Polytechnic, London, N.7 (October 15).

ASSISTANT BIOCHEMIST, Basic grade (with an appropriate science degree or Associateship or Graduate Membership of the Royal Institute of Chemistry) IN THE DEPARTMENT OF PATHOLOGY—The Superintendent, Northampton General Hospital.

ASSISTANT LECTURER (Grade B) IN ORGANIC CHEMISTRY—The Registrar, Hatfield Technical College, Hatfield, Herts.

ASSISTANT LECTURER, Grade B (with an honours degree in physics and research or industrial experience in some branch of applied physics) IN THE DEPARTMENT OF PHYSICS—The Registrar, College of Science and Technology, Ashley Down, Bristol 7.

BIOCHEMIST (Senior or Basic grade) to the Rochdale Group of Hospitals, to work under the Consultant Pathologist and to carry out biochemical work for the hospitals and clinics of the group—The Group Secretary, Rochdale and District Hospital Management Committee, Birch Hill Hospital, Rochdale, Lancs.

BIOLOGIST, to carry out research on certain aspects of *Tilapia* fish culture in East Africa—work to be based at the East African Fishery Research Organization at Jinja in Uganda and the Inland Fishery Research Station at Sagana in Kenya—The Director, Nuffield Foundation, Nuffield Lodge, Regent's Park, London, N.W.1.

BIOMETRICIAN, Scientific Officer or Senior Scientific Officer (graduate in mathematics with an interest in biology) IN THE SECTION OF STATISTICS—The Secretary, National Institute for Research in Dairying (University of Reading), Shinfield, Reading, quoting Ref. 60/10.

ELECTRON MICROSCOPIST, for work in cancer research—Dr. P. R. Peacock, Royal Beatson Memorial Hospital, 132–138 Hill Street, Glasgow, C.3.

HONOURS GRADUATES IN SCIENCE, to undertake physico-chemical research on biological macromolecules—Dr. P. Johnson, Department of Colloid Science, Free School Lane, Cambridge.

LECTURER (with a good degree, and preferably some training or industrial experience in the field of biochemistry) IN BIOCHEMISTRY—The Principal, Brunel College of Technology, Woodlands Avenue, Acton, London, W.3.

NUCLEAR PHYSICS EXPERIMENTALIST (with G.C.E. at "A" level, H.N.C. or equivalent experience in the experimental aspects of reactor or nuclear physics, and preferably an aptitude for mechanical devices), to assist as a member of a team in fundamental experiments investigating neutron spectra in moderators—The Personnel Manager (1726/34), United Kingdom Atomic Energy Authority, Atomic Energy Research Establishment, Harwell, Didcot, Berks.

PHYSICIST (recently graduated man), to join a small team of physicists and mathematicians concentrating on fundamental problems in applied mechanics which arise in long-range developments of new processes for metal forming—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, quoting MW/19.

RESEARCH FELLOW IN THE DEPARTMENT OF PATHOLOGY, to investigate the serological aspects of neoplasms—The Dean, Guy's Hospital Medical School, London, S.E.1.

RESEARCH TECHNICAL ASSISTANT (with H.N.C. or equivalent, a background of chemistry and physics, and good general laboratory experience) IN THE DEPARTMENT OF PROSTHETICS, to take part in the research in the properties of dental materials—Prof. E. Matthews, Turner Dental School, The University, Bridgeford Street, Manchester 15.

SENIOR LECTURER IN APPLIED BIOCHEMISTRY, to take part in the teaching of biochemistry and related subjects, paper chromatography, low and high voltage paper electrophoresis and ion exchange to H.N.C., B.Sc. and Grad.R.I.C. students and to Laboratory Technician courses as well as in the special and postgraduate courses—The Clerk to the Governors, South-West Essex Technical College and School of Art, Forest Road, Walthamstow, London, E.17.

SENIOR SCIENTIFIC OFFICER (with a first- or second-class honours degree in engineering or science, with at least three years post-graduate experience) at D.S.I.R. (Headquarters), London, S.W.1, for scientific administration duties—The Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting E.282/0A.

TECHNICIAN (with relevant qualifications and some experience) IN THE DEPARTMENT OF CHEMISTRY—The Secretary, Bedford College (University of London), Regent's Park, London, N.W.1.

TREE PHYSIOLOGIST in the Department of Northern Affairs and National Resources, to plan and undertake a research programme in tree physiology relating particularly to Douglas Fir in British Columbia—Civil Service Commission of Canada, Ottawa, Ontario, Canada.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences. No. 698, Vol. 243 (14 April, 1960): A Sedimentary and Faunal Study of the Blue Lias of Dorset and Glamorgan. By A. Hallam. Pp. 1–44. (London: Royal Society, 1960.) 17*s*. [254

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Centro Brasileiro de Pesquisas Fisicas. Notas de Fisica. Vol. 5, No. 14: On the Observation of Π Mesons Emitted in the Interaction in Emulsions of K⁻-Mesons. By M. C. Amerighi, F. Baldassare, M. Beniston, A. Bonetti, D. H. David, M. Di Corato, C. Dilworth, D. Ferreira, E. Frota-Pessoa, W. B. Lasich, N. Raina, M. René, J. Sacton and A. E. Sichirollo. Pp. 181–189. Vol. 5, No. 15: Paper Chromatography of Inorganic Ions in Nitrate Media. 2: Separation of Se–Te–Po and RaD–RaE–Po. By M. C. Levi and J. Danon. Pp. 191–195. Vol. 5, No. 16: Alguns Resultados Recentes Sôbre Equacoes Diferenciais Parciais Lineares de Coeficientes Constantes. By Leopoldo Nachbin. Pp. 197–206. Vol. 5, No. 17: On the Physical Interpretation of Complex Poles of the *S*-Matrix—I. By G. Beck and H. M. Nussenzveig. Pp. 207–253. (Rio de Janeiro: Centro Brasileiro de Pesquisas Fisicas, 1959.) [254

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